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NOTES AND COMMENTS.

Reconstruction.

The close of the war has come with the dramatic suddenness which certain wise souls vaguely predicted but themselves scarcely believed; and industry finds itself face to face with an entirely new set of problems. Fortunately, the experience of the last four years has aroused our national adaptability and foresight, so that we are far better prepared for peace than we were for war in 1914; but in many respects the peace problems are more urgent than the war problems, for the latter arose gradually over a period of many months, while the former are suddenly before us en masse.

In a general sense, the main problem is one of increased and more efficient production, to recoup the vast wastage of years of destructive effort, and this naturally involves a multitude of associated problems. Happiness of nations, as with individuals, depends to a large extent on prosperity, and under the new conditions prosperity will not be able to exist without a greatly increased output. Production, again, cannot be stimulated without industrial peace. The Whitley Councils, made up of employers and employed, provide one promising method of ensuring industrial peace and organisation. Complicated as the matter is, it is only one part of the problem. In this connection the recently issued Report of the Committee on Commercial Efficiency appointed by the Federation of British Industries makes interesting reading, and although a voluminous document, it is always terse and to the point, and is worth not only perusal but thorough assimilation in detail by those for whose benefit it has been published. On the very first page we find it stated that "no amount of co-operation between individual firms can be really effective unless the internal organisation of the individual firms attains maximum efficiency"; that is to say, you cannot have efficiency in the aggregate without efficiency in the component parts.

On the subject of production, to which much space is devoted, the Report recommends an interchange of statistics, standardisation of methods, and of working out of details of costing. Then follows a timely reminder that German manufacturers are already moving in these directions, and that the new systems are already being practised and are being further developed in the United States. A point new to the British manufacturer is the urging of sub-division and specialisation of manufacture, which have been so helpful to our German rivals, but this result can only be obtained by co-operative action, towards which voluntary associations in this country are recommended to work. The increase and improvement of output, it is suggested, would be furthered by the linking-up of manufacturers of intermediate products with the producers of the raw materials; this would, of course, form part of the machinery for the control of supplies—a matter of the utmost importance.

The necessity for technical education and for commercial training is also dealt with; our failings in this respect in the past constitute the reason why well-trained Germans have been able to obtain employment

in British works, and then to carry back to their own country the benefit of the practical knowledge acquired. To remedy the fault, the Report suggests permanent education committees in each industry as well as an efficient national system of technical education and commercial training. The Report closes with a very strong recommendation of the establishment of adequate research departments—a measure to which Germany owes much and the United States owe even more. If we are to hold our own—not to mention making progress—we shall have to take a leaf out of the book of both our rivals. As we have so often insisted in these columns, the foundry is particularly in need of the help of a proper research organisation to deal with the problems of its much neglected technology.

Training.

In connection with the general subject of training, we might recall the opinions expressed by Mr. Isaac E. Lester in his recent inaugural address as President of the Birmingham Metallurgical Society. He remarked that a revolution in scientific education would have to come, and come quickly. Their near neighbour, Coventry, with all its thronged industrial uses of metals, had no lectures of classes in metallurgy. That said much for the industry and patience of the specialists and experts engaged there on work of great national importance, and little indeed for the education authorities. It was the paramount duty of capitalists, economists, employers, and employed to demand and establish the necessary means of technical education and scientific research. It was essential to our national welfare that our future foremen, works managers, experts, and specialists should receive primarily the best general education the country could give, so that they might be enabled to express their thoughts clearly and put them on paper, and to put their ideas into practice. A connection should be established between the teacher or professor and the student in the works, with his Alma Mater as a referendum. The earnest worker should be relieved of the carking care of a livelihood during the probationary stages; no more junior works chemists at £1 a week or works chemists at 35s.

The "practical man," continued Mr. Lester, was a great national asset, but did they readily recognise the essentials of success in a practical man? If they meant mere rule of thumb or a cast of craft, they must needs relegate such knowledge to mere repetition work, practically standardised to a mere physical mental habit, calling for no original thought, resource, or experiment. A practice without theory was unwittingly a decadent practice, and the practical man in that case an automaton. Remove the everyday facilities, the habitual practice, the standardised materials, and the man was at the end of his resources. Here he would put in a plea for the future "practical man"—the youth with inherited practical instinct which a study of pure science would not give. A practical professor could not transmit the valuable qualities which were so essential in the study of metallurgy. Such a youth should have a good general education; his reasoning faculties should be developed on sound scientific principles, and his practical ability should have proper guiding. This kind of education, coupled with the necessary trade shop, or works practice and experience, should equip the youth with the means of thinking for himself and enable him to be observant, comparative, synthetic, and analytic in his work and profession. Then his powers of resource and research would give him, under variable conditions, the ability to deal with works problems, even such as might arise out of a world welter of war.

Slow Contraction of Hardened Carbon Steels.

It is a well-known fact that hardened steel contracts very gradually during a long period of time ranging over several months, this contraction being accompanied by a gradual evolution of heat, but the cause of the phonomenon is not yet clearly known. An investigation of it by Mr. Brush and Sir R. Hadfield led them to the following conclusion:—After being quenched, a hardened steel is in a highly strained state, and somewhat unstable, especially at first. Gradual relief of the strain causes a spontaneous generation of heat accompanied by a contraction of the specimen, until stability at room temperature is reached. But as has been already remarked by Mr. Brush, the quantity of heat evolved is too great to be accounted for by the relaxation of the internal strain caused by quenching. Hence the further study of its nature was very desirable, not only from the practical point of view, but also from theoretical considerations. Mr. Tokujiro Matsushita has recently re-investigated the phenomenon under the direction of Professor K. Honda, and has published his results in a recent issue of the "Science Reports" of the Tôhoku Imperial University. They are summarised by him as follows:—(1) In the case of imperfectly hardened steels, there is a gradual elongation, or an elongation associated with a subsequent contraction. (2) In well-hardened steels there is always a gradual contraction. (3) The elongation is explained by the incomplete Ar, transformation, while the contraction is due to the separation of an unstable cementite from its solid solution—the martensite. (4) The complete separation of the first unstable cementite at room temperature requires several months or over one year; but by heating the steel to about 100 deg. C., the same separation follows within two hours. (5) The separation of the unstable cementite does not affect the hardness of the steel appreciably; but the separation of the more stable cementite is associated with a loss of hardness. (6) The electric resistance of a steel considerably increases by quenching, and decreases by tempering; this increase is due to the cementite in solid solution. (7) The gradual elongation or contraction of quenched steel is always accompanied by an evolution of heat, which is the heat of transformation, but is not caused by yielding strain, as was generally supposed to be the case.

Suggestions for Saving Tin.

The Tin Section of the U.S. War Industries Board, after conferring with representative manufacturers of bearing metals, solder and other tin-alloy products, has published the following suggestion based upon experiments made by the U.S. Bureau of Standards:—(1) Many specifications for bearing metals call for virgin tin (Banca or Straits). A large saving of these high grades could be brought about by allowing the use of second quality pig-tin. Detrimental impurities could still be limited. There is no question but that the tin content can be reduced somewhat in all bearing alloys. In a few cases, such as for aeroplanes, crankshaft bearings, etc., it may not be feasible to reduce the tin content by any but a small percentage, whereas in other cases it can be cut down very considerably. (2) There is apparently very little excuse for using a 50-50 solder or higher tin solder for any purpose whatever except in the matter of appearance of the finished article, and in the present emergency this is of secondary importance. For hand-soldering with an iron 45-55 will answer for all purposes, but for most purposes 40-60 will be satisfactory. Wiping solder used by plumbers should not contain over 37½ per cent. tin, whereas many are now using 40-60. Can manufacturers and canners by adopting proper machinery can use 37½-62½ solder with satisfactory results. Very little solder of a higher tin content need be used in these industries. The possibility of using cadmium as a substitute for tin in solder appears promising. (3) It is also believed that the percentage of tin in most alloy castings is unnecessarily high. It has furthermore been found that aluminium, bronze, steel, brass or other materials can often be substituted in the manufacture of tin-alloy castings. Wherever possible the percentage of tin in the alloy should be reduced or another metal substituted.

Castings Used in Ship Construction.

By Ben Shaw and James Edgar.

Rudder—(cont.).

Preparation of the Mould.

The principles involved in preparing moulds to receive molten steel are similar in many respects to those which characterise the preparation of moulds for cast iron, but in practice the peculiar nature of the metal necessitates special provision for overcoming many of the difficulties which are encountered in a more intense degree than is the case with iron. In small castings the moulds are prepared in the usual fashion, vented in like manner to those for iron, but not quite so essential. The sand, however, is rammed very hard; in fact,

Fig. 1.—Preparation for Bedding-in.

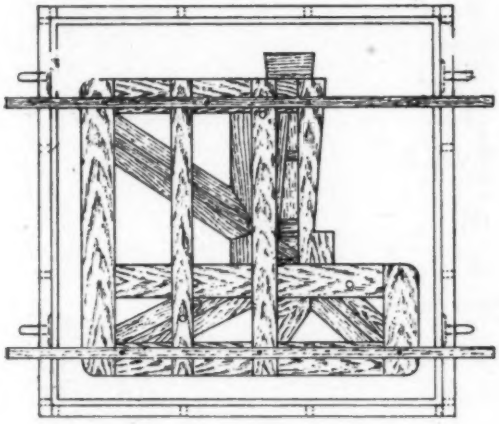


Fig. 2.—Section of Drag.

it cannot be rammed too hard, but the facing comprising the mould consists of a slightly different mixture to that for iron. Owing to the greater heat of the metal, a sand or composition of high refractoriness must be used, and the need for this increases with the increase in thickness of metal with which it comes into contact.

To meet demand for a special composition of this kind many firms supply what is termed "composite," and it is suggested for the benefit of those iron foundries where an endeavour is being made to assist in coping with the greater demand for steel castings for ships, to make use of these compositions, unless, of course, there is ample material at hand from which a good mixture can be milled.

A good composition can be made from broken crucible pots from which the flux, usually adhering to crucibles which have been in use for a large number of heats, has been freed, burnt ganister, or any other highly refractory material which has been in use in coke furnaces, old refractory bricks, clay from slate quarries, best hard foundry coke, all ground together in varying proportions, depending upon the degree of refractoriness required, and having water added to make it more cohesive. The loam used in steel foundries is of a similar composition, but contains more water, it being mixed to a consistency resembling that of lime. In appearance, the mixture is not unlike fire-clay, only coarser. Like the facing used for iron castings, once it has been in contact with the molten steel it is no longer fit to come into direct contact with the molten steel.

At the moment the men skilled in the art of steel

Fig. 3.—Half Pattern in Position.

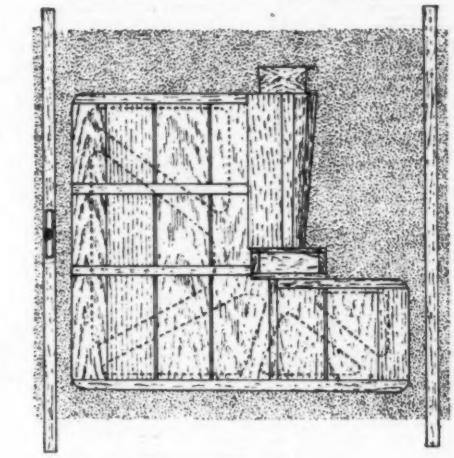


Fig. 4.—Preparing Bed.

founding are unable to cope with the increased output required, but skilled iron moulders who are experienced in dry-sand and loam work will readily acquire skill in preparing moulds for steel. Hence large foundries, being comparatively well equipped with labour tackle and machinery, can, by installing new plant, such as, say, a Bessemer converter, do much to assist in meeting the demand, and as the amount and character of the work involving steel castings is gradually increasing, the prospects of steady employment and the success of the venture is almost assured.

With the exception of very large unwieldy castings, the majority of moulds are prepared in boxes; this method is adopted in preference to others because of convenience in ramming, and also to render the successful drying of the mould comparatively easy. In many small steel foundries, however, where larger work is being undertaken than that which was originally antici-

pated when erecting their premises, difficulties sometimes present themselves in rolling over the box parts. The height of lift may be insufficient or the capacity of the crane unequal to the weight required to be lifted, while it is possible to divide the top box into two parts, it is necessary that the bottom should be whole. In such circumstances it becomes imperative to bed the pattern into the sand comprising the foundry floor or contained in a box part.

This latter method is shown in the illustration (Fig. 1) in connection with the moulding of the rudder. It will be noticed that a couple of straight-edged pieces of wood are screwed to the bottom half of the pattern and rest on the surface of the box part or drag. This method is the more necessary in this instance, because of the more fragile character of the pattern. When this bedding-in process is adopted for large flat work of

FIG. 5.—TOP BOX PLACED READY FOR RAMMING.

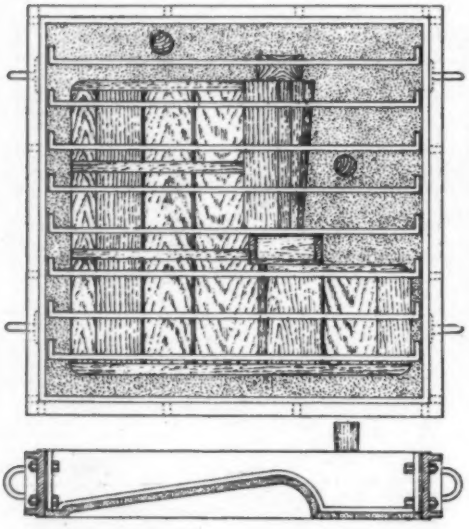


FIG. 6.—SECTION SHOWING ONE OF THE BOX BARS.

this kind it is advisable to leave the pattern as open as possible consistent with rigidity, to enable the moulder to have as much access for ramming. To bed in successfully requires considerable care and patience, for besides requiring very hard ramming, the sand must be of an equal density. The procedure is similar to that in bedding-in for cast-iron work, the box part being rammed up with ordinary floor sand until an impression can be made with the pattern, when the pattern being removed, an amount of this floor sand is removed from the impression thus formed, the amount removed varying with the thickness of composite required to take its place, in this instance being from about 1¼ in. in those parts when the resulting casting is composed of this metal to about 3 in. at the thickest parts. It is safer to have too much composite than too little.

When this has been done and the composite facing applied, the pattern is again used in securing an impression, much pressure being used in forcing it down until the straight edges or battens find a bearance on the box sides. Often hammers are used in applying the requisite force, and although the pattern may be protected in the process, it certainly has a damaging effect.

Another means of doing the work which gives a regular pressure over a larger surface can be adopted by lowering a large casting right on to the pattern. In obtaining a regular density of sand beneath the pattern, it will be necessary to remove it a number of times, easing those parts which will not allow the pattern to take up its correct position and filling in when the density is unstable. When finally the pattern is bedded in, proceed to ram up the remaining parts until the joint is reached, when the battens can be removed, and preparation made to receive the top half of pattern and box.

FIG. 7.—SECTION THROUGH CENTRE, WITH GATES AND RISERS.

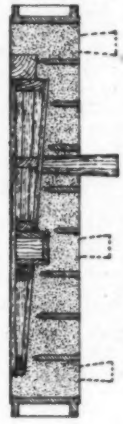


FIG. 8.—GRID FOR RUDDER POST CORE.

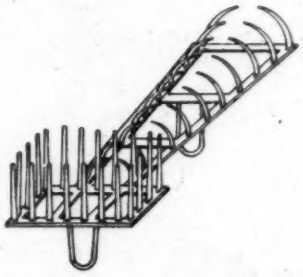
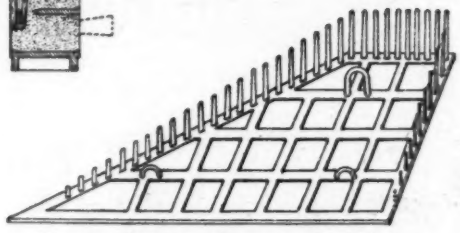


FIG. 9.—GRID FOR CORE BETWEEN RIBS.



While the bottom half of the pattern has been left as open as possible, the top portion can be covered, ensuring greater ease in ramming up the top of the mould. A section of the drag showing the battens is shown in Fig. 2. The box parts used in many foundries are bolted together, and slot holes are cast in the joint flanges for assisting to secure the parts together when casting. Numbers of holes are also cast in the sides, so that loose bars can be made to accommodate the work for which the box parts are suitable, and bolted into a position, following the contour of the pattern, and about 1 in. from it. The method is useful in the sense that it reduces the number of boxes kept in stock, which occupy valuable space, often in the foundry itself.

The method illustrated in Figs. 1 and 2 is one of expediency; the usual process of preparing moulds for such castings as indicated is by rolling over. This is accomplished by making a level bed

in the foundry floor, as shown in Figs. 3 and 4. It is not essential that the bed should be level, but it is very necessary that it should be out of winding, hence the simplest way is to make it level by bedding into the sand floor a couple of straight-edged logs, using a level while setting them, as in Fig. 3, and by means of the level and a parallel straight edge determine their relative position. When the logs have been set and sand rammed about them to prevent them moving, the whole bed can be prepared. It is preferable to ram fairly hard and so reduce the labour required in making the joint after the box has been rolled over. When this bed has been made the bottom half of the pattern is laid in position, the logs removed, and their impression filled up, the remainder of the bed dusted carefully with parting sand, and the box part lowered over.

It is customary when adopting this method to use

Fig. 10.—Cores in Position.

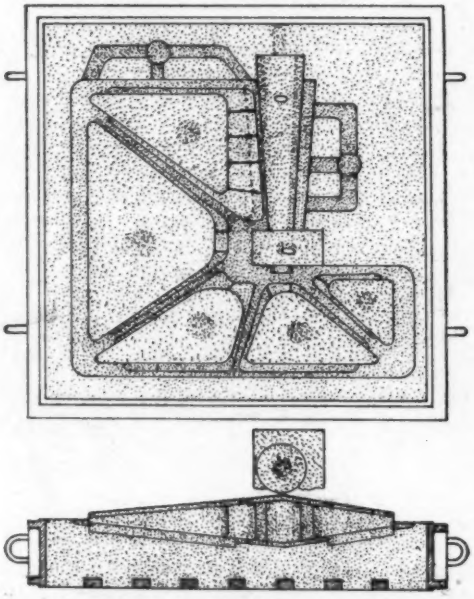


Fig. 12.—Section through Mould preparatory to setting Rudder Post Core.

similar box bars to those used for the top, but care must be taken to ensure freedom for whatever runners may be required. Ordinary single bars may be used having flanges at each end, as illustrated in Fig. 5, or double bars may be bolted in. In the latter case the ends of the box become the flanges; hence the same number of bolts are required to secure the two bars as would be necessary for each of the single bars shown in the illustration. Both kinds are used, however, their value being determined by the character of work in hand and stock supplies suitable. Reverting to Fig. 3, the dotted lines shown represent the position of the prints. It will be readily seen and understood that when a bed is made in this position and the bottom box rammed in an upside-down position, a more regular density of sand is obtained and the facing sand can be regulated in depth much more easily.

When this box has been tightly rammed up, the whole is turned over. For this instance, where the weight of the pattern is considerable and the depth not great, it is advisable to set into the pattern a few screw eyes, and by passing a bar through them and wedging it against the box prevent the possibility of the pattern falling out while being rolled over. The joint having been sleeked over, it is ready to receive the top half of the pattern and the top box.

The top half of the pattern is lowered into position, determined by the dowels, and the sand forming the joint is dusted with parting sand. It may be necessary to be quite sure that the two halves of the pattern are quite close together. In the case of a pattern for a rudder the edges are comparatively light in construction, and, being in halves and subject to varying conditions, there is a tendency for them to curl. A number of weighty

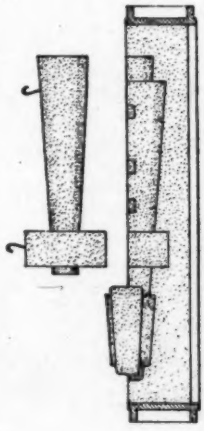


Fig. 11. — Section of Mould with One Core Set.

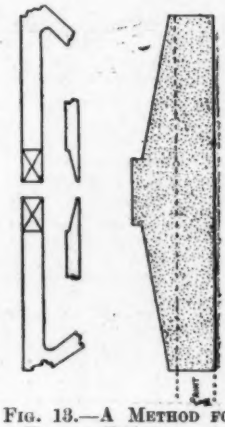


Fig. 13.—A Method for Easing Strain in the Casting.

pieces of metal placed on top of the pattern will be sufficient to ensure a more reliable impression. Proceed to set the top box in position, its relation to the bottom box being determined by pins, or whatever method may be usually adopted, providing it ensures a safe lift and a return to its former position. Define the most suitable places for running the job and set in gate sticks; their position will depend upon whether the job is to be cast vertically, horizontally, or on a bank. In very large work it is often impossible to cast vertically, though greater success is likely to result if the work can be so arranged. To cast the rudder horizontally two gates would suffice, each about 3 in. in diameter.

In some foundries runners suitable for various-sized castings are stocked and set into position while the work of ramming is proceeding. These are in the form of blocks, composed of ganister and firebrick, and are capable of withstanding the heat of the molten metal for a longer period than if formed from the ordinary composite mixture. Runners can, however, be made on the job if it is remembered that special care is required in their formation. Risers should be carried off at the

higher points, with special attention to those parts consisting of a heavier body of metal.

In our illustration the metal surrounding the pintle is very thick; hence it is wise to bring off a substantial riser, thus allowing the casting to draw upon the riser at that point, rather than the arms or ribs connecting it with the outside framework. Proceed to ram up the top box in a similar manner as when ramming the drag box previous to rolling over.

Fig. 6 shows a section of the top of the mould, and illustrates a proximate relation of one of the box bars to the mould, and showing clearance with the sides of the box for convenience in moving it into the position before bolting up. Fig. 7 shows a section through the centre in a line with the vertical centre of the rudder post, and showing gates and risers. When the job has been rammed up satisfactorily, the gates sticks are withdrawn and the top box lifted.

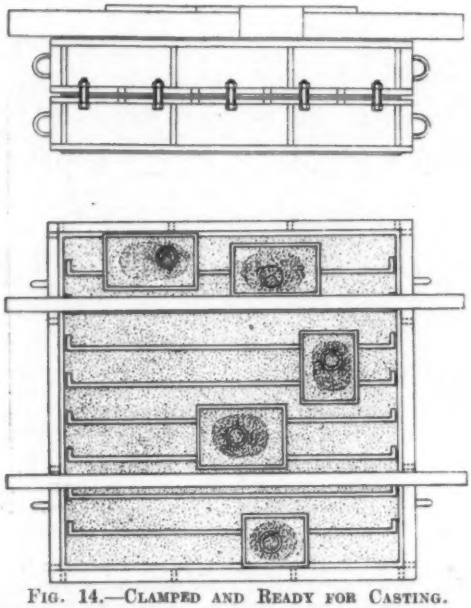


FIG. 14.—CLAMPED AND READY FOR CASTING.

Again it is necessary to provide for the half pattern being retained in the top of the mould, so that a better lift may be ensured when the box is turned over. Swab the joints and sleek off, marking out the position and number of the runners required. In sleeking the joints it is safe to cut away or compress the sand, following the contour of the pattern, so that a substantial fin will be formed on the casting, providing a cleaner edge and a way of escape for gases formed.

Withdraw the two halves of the pattern and clean up in a manner similar to that adopted for a dry-sand mould to receive cast iron. To stiffen the body of the mould be unsparing with 3 or 4-in. moulder's nails, more especially around edges which form a definite corner in sand. Make up the runners in the form of a spray, their area depending upon the size of the gates. Clear away the corners in the top box where the runners and risers form a junction with the bottom box, as it is necessary to avoid any possibility of corners crumbling during the time of pouring and running—a danger to the casting.

The necessity of following the same precaution with the risers will enable these to be used as gates, should it be advisable to do so, when running the job. In the body of the mould surrounding the thicker portions of the metal a number of prod-holes are often inserted having a diameter of about ¼ in. and about 2 in. in depth. These prods or dabbers are useful in carrying off impurities, and also offer a means of escape for gases, which may otherwise be unable to find an exit.

The mould now requires to be thoroughly dried. If a portion has been formed in the foundry floor, then fires must be arranged to dry it in place,

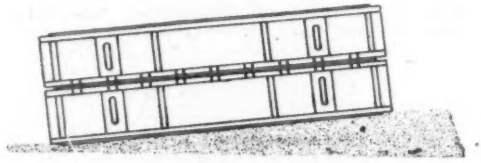


FIG. 15.—PREPARATION FOR CASTING ON A BANK.

supporting the top box over it, and scaling the sides as much as possible with plates. If it is possible, however, it is preferable to place both top and bottom boxes on a bogie and run them into a drying stove. The nature and composition of the sand renders the possibility of any damage through overheating extremely unlikely, and in this differs from the sand composition for iron moulds.

During the time the formation of the mould has been in progress the cores will have been receiving special attention, and considerable care must be exercised in their construction. For iron castings the contraction to be taken into account varies slightly according to the nature of the work and

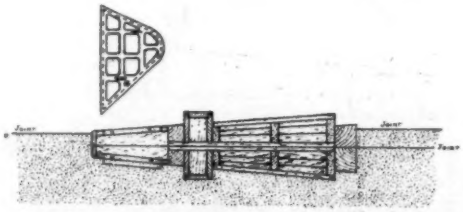


FIG. 16.—PATTERN SCREWED TOGETHER AND BEDDED INTO FOUNDRY FLOOR READY FOR MAKING CORES IN THEIR RELATIVE POSITIONS.

the method of casting, but for general purposes it may be considered to be 1-10 in. per foot; but in steel casting the general allowance for contraction is between 5-32 and 3-16 in. per foot, and this creates one of the greatest difficulties with which steel moulders have to cope.

In our present illustration the outside of the mould offers practically no resistance, but all the cores are under compression, and unless great care is taken in their construction to allow them to be crushed, the casting will break or twist out of shape. Many contrivances are adopted to minimise the possibility of such disastrous results, their one object being to ease the resistance offered and make the places where compression is greatest yield to

the contraction of the casting. The difficulties are increased by the comparatively sudden manner in which contraction takes place, and as the composition forming the face of the mould dries into a very hard mass resembling concrete, the formation should be so weakened in certain parts that, while it offers sufficient resistance to the pressure of the molten metal, it yields under the pressure of the contraction. Just as the mixtures of loam differ for iron, so do the mixtures for the preparation of cores for steel casting.

A composition suitable for cores used in the rudder is made by reducing the strength of the composite previously explained by adding silver sand, and to render it more plastic for working white lead might be added, using coal tar in the place of water. Cores made from this mixture possess a very hard surface after being dried, but it is advisable to complete the work on them while the sand is in a green state and ready for blacking, as, though the skin is hard, should it be broken the interior composition is weak and rams freely.

Figs. 8 and 9 show the formation of two of the grids required for the cores, the former being for the rudder-post core and the latter for the largest core between the ribs. The prods, which can be made of pieces of wrought iron cast into the plate, should be clear of the outside of the core by an amount varying with the contraction of metal about it. Thus the clearance in the case of the rib cores should be more than for the rudder-post core, and, seeing that wrought-iron prods give more readily to pressure, they are often used in preference to cast prods. In constructing the cores a bed of the weakened composition is formed about 1 in. thick and the grid bedded into it, the sides being then made up with the same composite about 3 or 4 in. thick, the inside being filled with ashes and a thin covering of composition loam on top.

For the cores between the ribs in this instance the inside of them can be left open, having only a body of sand surrounding the sides, and sufficient to form the contour of the print. Care must be taken, however, when closing the mould, to ensure the top finding a bearing on the cores, and thus cutting off any possibility of the metal finding a way inside of them. Both these methods reduce the strength of the cores and allow them to give to the pressure when shrinking takes place.

The same method is applied to the rudder-post core, but the coating of composition can be much thinner; 2 to 2½ in. will suffice. When these cores have been stripped and sleeked off, a number of parts are cut to form brackets on the casting. These brackets are cast on to counteract the tendency of the casting to become rent or torn asunder during the time of cooling, owing to sudden shrinkage. They should be used wherever the thickness of metal varies abruptly, their size depending upon this variation, but usually about ¼ in. in thickness. These ribs are knocked out when the casting is cleaned.

When the cores have been prepared in this manner and swabbed over with a thin mixture of composite and water, they are dried. When both mould and cores are dried, a considerable amount of care must be exercised in finishing; any cracks which have been formed in the surface of them must be filled up and coated with a liquid solution of composite and the best plumbago, or for heavy large cores with coal-tar. It is usual, however, to use the former mixture when the parts of the casting coming in contact with it are to be machined. After being assured that the cores and mould are thoroughly dried, a commencement can be made to close the mould and prepare for casting.

Just as it is desirable to provide a fin about the joint of the mould, it is equally as valuable round the cores. The impressions left by prints should be tapered off at the junction with the mould about 2 in. back, and the tops of the cores should be chamfered off in like manner. Besides being useful for the purpose previously mentioned, they prevent the likelihood of crushing the corners when closing. In Figs. 10, 11 and 12 the setting of the cores is illustrated, Fig. 10 showing all cores in position and the bottom of the mould ready to receive the top box, the contraction brackets being shown by thick black lines. The thick dotted lines shown in the centre of the cores are for venting purposes through the top box. It is, however, unnecessary to insert pipes, a number of vent-holes through the top at these places being sufficient.

When the top box has been finally lowered, after runners and risers have been found to coincide with the positions required, and the bearing on the cores and joints has been assured, pouring and riser basins previously prepared are set in position and daubed round the outside with loam. The two runner basins can be connected and used in conjunction, but it is often preferable to run into each separately. Fig. 14 shows a plan and elevation of the mould ready for casting. These basins are made fairly large to provide a good head of metal suitable for feeding the casting while shrinking.

The illustrations show the box part secured together by means of bolts, which is a very useful method of providing the necessary resistance to the pressure of the metal, although in many cases weights alone are used for this purpose when the job is cast in a horizontal position as shown. Much more care must be exercised in securing the boxes when the work is cast vertically; the head of metal is then greater, hence the pressure exerted will be increased. Steel sets very quickly owing to its composition, and its fluidity is reduced by reason of the carbon contents; hence the milder the steel the less the fluidity. In such circumstances it is of the utmost importance to cast in a vertical position whenever possible, or at least on a bank—that is, inclined at an angle, thus assisting the metal in its progress through the mould. Compared with iron, owing to its thickness and more lazy movements, a much longer time is required to fill a mould with steel. Apart from this, it is common practice to pause a few times when casting to allow the gases to escape, while the pouring is proceeded with at another.

When the job has been cast, the riser head should be given a supply of hot metal from the ladle. When such a job is cast on a bank, as shown at Fig. 15, it can be run in a similar manner as that shown for the horizontal position, but the basins for the heads should be carried up level and a riser brought off the top of the metal surrounding the rudder-post.

The method described for preparing the mould for this rudder is suitable when the pattern is blocked up and the cores are made separately, but it is quite common practice in steel moulding to prepare the majority of the cores in the mould.

Both methods possess disadvantages. When cores are made separately more men can be at work on any given job; hence it is likely to be turned out more quickly in the foundry, but the difficulty of making suitable allowance for shrinkage is usually

greater. Successful results, however, are obtained from both methods, and it depends very greatly on district customs which method is adopted. With the exception of the rudder-post core, which would of necessity require to be made separately in any case, all the cores can be made in the mould. The bottom half of the pattern would be laid on a prepared bed as previously described, the drag-box set over it, and the whole rammed up, but in between the ribs should be filled with ordinary floor sand, and prints formed on the top being finally rammed up. When the box is turned over, this temporary sand is cleaned out, and the other half of the pattern laid in position.

The cores are built in a manner similar to that adopted with a core-box, but while the consistency of the composite forming a bed for the grids will be in the nature of loam, and similar to that used in the previous method, the rest of the core can be rammed up; the same discretion is necessary, however, in weakening the composition. All pieces on the pattern likely to interfere with the successful drawing of the core should be loosened.

When these cores have been built up, with cinders as the central contents, and having small pieces of sheet-iron over the lifting staples, so that their position may be easily defined, the top box can be lowered over, similar provisions made with regard to runners and risers, and rammed up as previously described. In this instance the top half of the pattern will remain down when the top box is lifted; hence any portion likely to cause a bad lift should be made loose, so that it can be taken away in the top. Parts of the pattern which can be moved before the cores are lifted are removed, and when all the cores have been successfully withdrawn the main portion of the pattern can be taken out, and the cleaning of the mould and cores proceeded with, including the provision of brackets and dabbers and the insertion of moulder's nails.

Patterns of this kind are sometimes of a very frail nature, and while they may be constructed in halves in the pattern shop for convenience, they are sometimes screwed together at the foundry and bedded into the floor as shown in Fig. 16. In this way the joint of the mould can be altered to reduce the amount of lift in the top. The construction of the mould is the same with this exception, but being bedded into the foundry floor determines the position in which the job is to be cast; hence, if it is desired to cast on a slope, it must be bedded at the angle desired.

In providing the molten steel for such castings, a Bessemer converter is usually installed, which receives a charge of molten metal from a cupola, where it is subjected to a blast of air at a pressure of 15 to 25 lbs. per sq. in. until all the carbon is burnt out. When this method was first used a metal rich in manganese was used and converted until the desirable carbon content was obtained. This, however, was very difficult to regulate; hence the results were very uncertain. The process now employed is to continue with the blast until all the carbon is burnt out, a point more readily determined; but this would contain too much oxide and provide a poor steel owing to its tendency to crumble; a manganese mixture is added which has a stronger affinity for the oxygen than the iron, and provides the necessary amount of carbon. This mixture is termed Franklinite or spiegeleisen, and is added to the mixture in the converter in a molten form, giving a more definite result with less inconvenience and more economy. Pig-iron treated in this way must be practically free from phosphorus, as that element is not removed in the converter and renders the steel both brittle and unmalleable.

The lining of the converter is heated until it is red-hot, and the fuel discharged before the molten metal is run in. When the metal is in, it is subjected to a stream of air, and as the carbon begins to burn, increasing in volume and brilliancy, the metal gradually grows hotter and boils up, causing the converter to tremble to its foundations with its violent ebullition. On the metal becoming decarbonised the flame is reduced and loses its brilliancy. This occurs after the blast has been on about 20 minutes, and is the critical point of the process. The converter must be turned, the blast turned off, and the Franklinite added, when another flaming reaction occurs. The blast is turned on again to ensure a thorough mixture, but only for a very short time, when it is ready for pouring into a previously prepared ladle. The metal is a dazzling white, and is followed by a blanket of slag.

In pouring the metal into the moulds, the method differs from that for iron, as it is run from the bottom of the ladle, when required, by moving a nozzle stopper controlled from the side of the ladle. The slag encrusts itself round the top of the ladle, and usually remains there as the metal runs out from the bottom.

When the job has been successfully cast, and the heads broken off while hot, the process of easing must follow as quickly as possible, and the casting must be removed from the moulding box at the earliest moment. This tends to increase the speed of contraction.

In rudder frames a method of releasing strains is sometimes adopted by inserting a core in one of the sides as shown in Fig. 13, the portion which is out being made a convenient shape for scarfing an extra piece in after the work has been cast and annealed. This alteration is usually made at the foundry, and is done simply to reduce risks.

Annealing must be resorted to in all these castings, the effect being to dissipate the internal strains. The casting should be supported in a sealed furnace, the temperature of which is gradually raised until the casting becomes heated to such an extent that the parts formerly in compression or tension contract or stretch, and thus cease to act upon each other. While it is necessary that the increase in temperature of the annealing furnace should be gradual, it is more essential that the reduction in temperature should be slow and gradual, so that whether the parts of the casting are slender or massive they will cool at the same rate, and thus ensure the absence of all stress when it is finally cooled.

SEMI-STEEL SHELLS.—Colonel Martinon, head of the French technical mission of ordnance experts, now touring in the States, was to deliver a lecture on "Semi-Steel Shells," at the recent annual meeting of the American Foundrymen's Association. For several years semi-steel shells have been cast in French foundries. The French process has been developed to a high state of perfection, and in his address, Colonel Martinon was to describe all details of manufacture, including methods of moulding, core making, melting, etc. He was to be accompanied by a large number of ordnance engineers, technical experts, and shop foremen, who constitute this mission. The visit is the result of an agreement with the French Minister of Munitions and the Chief Ordnance Officer of the American Expeditionary Forces.

Magnesites and Magnesite Bricks.

In a Paper read by MR. W. DONALD recently before the Ceramic Society, the author treated the subject chiefly from the manufacturer's point of view.

Magnesite bricks are made in our own country chiefly from Greek and Indian magnesite, but besides the well-known Austrian deposits, many other countries contain the material in considerable quantities. Refractoriness in the case of magnesite bricks has relations with the density, porosity, tensile strength, resistance under load at high temperatures and chemical composition. In order to have control of these factors, a full knowledge of the raw magnesite is necessary, including the nature and amounts of mineral impurities, the effects of heating at different temperatures for different periods, with slow or rapid cooling, and with oxidising or reducing atmosphere, with or without previous elimination of certain impurities or the addition of other materials. Important information is obtained by detailed microscopic examination of both raw materials and finished products, as the causes of physical changes, and the course they take, may often be traced in this way.

Greek magnesite has usually more silica and lime, but much less ferric oxide, than Austrian magnesite. In the finely crystalline Greek magnesite the mineral impurities—more especially the oxide of iron and alumina—are distributed very irregularly, which increases the difficulty of satisfactorily calcining the mineral throughout in a single firing. Canadian magnesite deposits are even more irregular. In the author's opinion, by careful selection of the material, Greek magnesite could be made to compare much more favourably with Austrian magnesite as regards silica and lime content.

In comparing sections made of Greek magnesite bricks fired at 1,750 deg. C. and 1,850 deg. C. with similar sections of Austrian bricks, it was seen that the faces of the Greek bricks nearest to the source of heat were quite fused; half an inch from that face the structure of the bricks showed change from small to large crystals, but where large crystals had been formed no bad effect of heat was noticeable. Austrian bricks showed no sign of being fired at a high temperature. In the Austrian bricks the magma is practically uniformly distributed throughout the brick, and had interpenetrated each particle. In the British-made Greek bricks the magma is not so evenly distributed, but after successive spallings the brick is converted bit by bit into the larger crystal formation, when the impurities present in the magma often give rise to a frothing with great porosity. The silicates of magnesia present are bulky and highly viscous, and must be almost immovable as a molten liquid at 1,650 deg. C., though they melt at 1,550 deg. C. Hence the author thinks ferrous iron must be introduced. In this connection it may be recalled that Austrian magnesite has ferrous carbonate regularly distributed through the mass.

Dr. A. Scott shows that magnesia compounds and lime compounds have melting points between 1,500 deg. C. and 1,550 deg. C., and any compounds, including both the magnesia and the lime, have melting points at least 150 deg. C. lower. This implies that lime should be eliminated as far as practicable, and that what lime is present should be uniformly distributed along with the other impurities, and therefore the magma which is formed should have a consistency which will not offer too great an obstacle to the uniform distribution.

The results obtained with British made bricks used in basic open-hearth furnaces, pig-iron mixers, Talbot furnaces, and electric furnaces are on the whole satisfactory from the steelmakers' point of view. Difficulties are still experienced from spalling, from inability to withstand the corrosive action of basic slag and inability to stand the great heat in the roofs of electric furnaces. In one electric furnace seventy-five heats were now obtained with Greek magnesite bricks for the same life of magnesite lining which formerly with Spaeter (Austrian) bricks gave 120 heats. In another electric furnace the Austrian magnesite bricks in the side walls withstood the action of the molten steel and the basic slag without showing the frothing and porosity to be seen in the Greek bricks. In another electric furnace it was possible with Austrian bricks to get good results in the roof even with less experienced furnace hands than those now available.

Generally speaking, two main types of magnesite oricks are on the market; one type is made from finely ground material, and weighs about 72-76 cwts. per thousand, sometimes up to 80 cwts. per thousand; the other type is made from less finely ground material, and weighs 82-86 cwts. per thousand, or sometimes up to 88 cwts. per thousand. In sections of the former type finer particles are to be seen, and, on the whole, a more complex colour scheme; in the latter there is greater light and shade between particles and magma and also between different particles. These points were demonstrated with the aid of lantern slides, and the structure of particles and the distribution of particles and magma in various bricks were shown. By comparison with sections of calcined magnesite, it was shown that a large percentage of particle in British-made bricks remains in the state of calcined magnesite, and that the impurities (magma) surround the particles rather than interpenetrate them.

Sections of Indian and Greek magnesites calcined at about 1,250 deg. C. showed minute granular forms. Indian magnesite calcined at 1,750 deg. C. in an electric furnace showed alteration taking place, which was greatest at places where impurity was present. Greek magnesite electrically calcined at about 1,900 deg. C., showed that the particles had completely altered about the impurity and that the alteration had spread round. Greek magnesite calcined much longer at a lower temperature (in a modern shaft kiln under highly reducing atmospheric conditions) showed the change of mineral particle to have practically spread throughout the mass. There was a strong resemblance between the massive crystalline appearance now in the Greek magnesite, even where there was no coloration, and the lighter parts of Austrian bricks, though there was still some difference, but the author confidently expressed the opinion that in the economical course of manufacture the minute magnesite crystals in the raw Greek magnesite could be converted into the kind of crystalline material naturally present in the Austrian bricks. It had been stated that the Austrians calcined in rotary kilns; though shaft kilns were used

originally, but the author considered there would be great difficulties in using rotary kilns under suitable conditions for calcining an appropriate mixture of Greek magnesite and ferrous carbonate. He thought the modern gas-fired shaft kiln could best answer the needs of magnesite brick-makers whose raw materials were in the crypto-crystalline state.

A pressure of 300 tons has been reported as being applied in the moulding of Austrian magnesite bricks, but the author considered that even with the pressure used here it was possible, with suitable adjustments of the milling and moulding plant, to increase the weight of the bricks from the standard of four tons per thousand to 4¼ tons per thousand, as against 4⅝ tons per thousand for the Austrian bricks.

The author's main conclusions, drawn from microscopic examinations included the following:—(1) With proper application of heat crystal growth can take place more quickly and regularly if there is a uniform percentage of impurity throughout the magnesite. (2) The impurity-magma should be able to interpenetrate the finest interstices of the magnesite particles instead of merely coating them; otherwise the proportion of impurities should be correspondingly less. (3) If these particles are unaltered from the crypto-crystalline state by calcination, the alteration takes place when the bricks are in use, and after repeated spalling the section of the brick with altering particles is exposed to the direct action of slag which can penetrate the pores, causing frothing with greatly increased porosity. (4) By proper management the conversion from the crypto-crystalline state to the larger crystal growth could probably be attained more uniformly than has been done hitherto. (5) When ferric oxide is present, the conversion of the crystal growth from the crypto-crystalline to the massive crystalline is much more uniformly attained within a certain distance from the ferric oxide, and the resulting material is closely comparable to the Austrian product. (6) British-made magnesite bricks most closely corresponding in micro-section to the Austrian magnesite brick, both in regularity of growth and as regards the microscopic appearance of the magma, are those which have given the best results in furnace linings.

Time Effect in Tempering Steel.*

By A. E. Bellis.

The time effect in reheating certain steels below the critical range is very marked. In tempering it is most important when a maximum drawing effect is desired, in which case the highest physical properties as well as ease of machining are important considerations. These are the conditions in drilling a rifle barrel, and anyone who has been connected with rifle manufacture knows how seriously production is affected when "hard" or non-uniform steel for barrels is encountered. The importance of high physical properties (tensile strength, toughness and resilience) in a rifle barrel is obvious.

The physical properties of two different lots of barrel steel are given below. The first lot, No. 1, gave serious trouble in the drilling operation; the second gave no trouble at all.

	No. 1.	No. 2.
Elastic limit, lbs. per sq. in. ...	117,450	116,800
Tensile strength, lbs. per sq. in. ...	152,500	151,750
Elongation, per cent.	16.0	20.0
Reduction of area, per cent. ...	42.1	51.0
Impact strength, ft.-lbs. per sq. inch	450.0	520.0

This difference in machining and physical properties was due entirely to the time of reheating. The first lot was given a reheating time of 30 min., the second lot remained at the reheating temperature 2 hours. Both lots had been oil-quenched from 1,500 deg. F. and reheated to 1,180 deg. F. The time required in the reheating or drawing for the work to come to temperature was not counted. This time was approximately 20 to 30 minutes. The steel used has the following composition: carbon, 0.54; sulphur, 0.050; manganese, 1.22; phosphorus, 0.065. The physical properties when untreated are as follows:—

Elastic limit, lbs. per sq. in.	69,800
Tensile strength, lbs. per sq. in.	128,700
Elongation, per cent.	15.0
Contraction, per cent.	35.2

Further experiments established the fact that at least a 2-hours reheating is necessary in order to have satisfactory machinability. Steel which, after treatment, gave elongation of 20 per cent. or over gave no trouble in the shops. These results were confirmed by reports on thousands of barrels. It will be noted that there is a decrease in the elastic limit and tensile strength as the drawing time is increased, but that this is slight compared to the relatively great increase in ductility.

A similar test with differently-heated lots of steel indicates that further increase in machinability, ductility, and resilience can be obtained by making the drawing time still longer. Below are the results of this test (A) with drawing periods of 1, 2 and 3 hours; together with the results of another test (B) made with drawing periods of ½ hour and 12 hours. The latter test was made with the idea of producing the maximum time effect.

	A			B	
	1 hr.	2 hrs.	3 hrs.	½ hr.	12 hrs.
Elastic limit ...	124,250	121,600	116,250	115,500	98,750
Tensile strength	131,000	135,600	125,900	135,400	116,500
Elongation, per cent.	17.0	17.5	19.0	17.5	22.0
Reduction of area, per cent.	42.2	45.4	47.6	52.7	57.2

In order to determine whether this effect was largely due to the high manganese content of the steels, an ordinary machining steel of the same carbon content was given a similar test. The steel analysed: carbon, 0.53; sulphur, 0.036; manganese, 0.65; phosphorus, 0.049. The same tendency was noted.

In all these experiments the standard test specimens were prepared from the bar stock *after* the heat treatment. The original diameter of the stock was 1 1-32 in. The reheating time was not counted for the first 20 or 30 minutes necessary for the pieces to reach furnace temperature. A reheating time of ½ hour, therefore, means at least 50 minutes in the furnace. For quenching, a straight mineral oil was used of 0.890 specific gravity at 60 deg. F., 400 deg. flash point and 200 sec. Saybolt viscosity at 100 deg. F. The excellent physical properties that can be obtained by properly heat-treating a machinery steel containing 1 to 1½ per cent. manganese does not seem to have been generally recognised.

* "Transactions of the American Institute of Mining Engine

Occlusion of Gases in Metals.

A general discussion on the occlusion of gases in metals took place at the meeting of the Faraday Society last month. Sir Robert Hadfield, F.R.S., presided.

PROPERTIES OF METALS AS AFFECTED BY OCCLUDED GASES.

By Cosmo Johns.

It has long been known that the properties of metals are affected by the occluded gases. The behaviour of copper and iron after exposure to hydrogen under suitable conditions are striking examples of profound changes in properties due to the absorption of gas, and suggests that the effect of the gaseous constituents of the metals used for constructional purposes, where tenacity and ductility are the desirable properties, may be more far-reaching than is sometimes suspected. That their significance is not fully realised may be seen from the small number of researches on the industrial metals in which their gaseous constituents are correlated with their physical properties. Much work has been done on the absorption of gases by the pure metals, but there is still a lack of knowledge in the case of many of the industrial metals and alloys as to the exact conditions which determine the absorption of the various gases that have been found in the finished product.

The custom of using the term "occlusion" without an adequate definition of what is really meant, to cover the complex changes that must occur when various gases are absorbed by, and become constituents of, many metals, has probably helped to retard progress. To take two simple cases, the absorption of hydrogen by molten copper must follow laws that differ from those that obtain when oxygen enters into combination with that metal. The process of absorption of CO by iron must be greatly affected by the temperature at which absorption takes place, and it is certain that above the critical range the process must differ from that which occurs below that range. It is also probable, if not certain, that some gases that can be extracted from metals by suitable means were not originally absorbed as such, but were formed as a result of reactions between non-gaseous constituents during the cooling of the metals in question. To include these very different phenomena under the head "occlusion" can but favour confusion of thought and hinder progress. If we retain the term "occluded gases" to define those gaseous constituents of the metals which may be extracted from them, and leave for further investigation to determine which, if any, of them had been "occluded" or absorbed as such originally, this objection would be removed.

Probably the most instructive researches on the change of properties by a metal as the result of the absorption of gas were those of Heyn on copper and hydrogen, where he was able to show that the absorbed hydrogen acted from the exterior inwards, and that it induced brittleness in ductile specimens of that metal. He was also able to show that heating steel, which had previously absorbed hydrogen, in air or nitrogen expelled the hydrogen, so that in this particular instance we evidently have a case where the absorption and expulsion of the gas is determined by its own partial pressure and the heating in a vacuum shown to be unnecessary. The metal is evidently permeable to the gas, and is permeated at a rate depending on its partial pressure, and yet can retain in the cold that gas in a form which profoundly affects the physical properties of the metal. Roberts-Austen and Heyn investigated the effect of hydrogen on iron, and demonstrated that ductile iron or steel was rendered brittle when it contained hydrogen. These cases cited serve to indicate the nature of the changes which take place when even one gaseous constituent of the metal is considered.

The absorption of hydrogen by copper and iron will serve as typical cases of what is known as "occlusion" of gases by metals. It might therefore serve some useful purpose to discuss the probable mode of association of this gas with the metals of which it is a constituent. Current views may be summed up as an assumption that it is a case of solution, but it is not generally indicated why a solid solution of hydrogen in those metals should behave so very differently from the gas-free metal. If, however, we reject the theory of a solid solution of hydrogen and copper or iron, and assume as a working hypothesis the solubility of the gas in liquid copper and iron, but its insolubility in the solid metals, a promising method of explaining the observed facts will become available. In a metal like copper or iron, when heated or cooled within a range of temperature that did not permit grain-growth, the absorption or expulsion of hydrogen would, under the hypothesis assumed, chiefly, if not entirely, affect the intercrystalline undercooled liquid, and relatively small quantities of hydrogen might cause profound changes in the properties of the solid mass. That the "amorphous" intercrystalline matter will have a greater solubility for hydrogen is certain from the behaviour of the solid and liquid metal after exposure to hydrogen; what is now suggested is that this greater solubility of the "amorphous" matter is the dominant factor in the embrittling of steel when exposed under certain conditions in an atmosphere of hydrogen.

After a brief review and discussion of these and other known facts and reasonable influences the author submitted the following points:—(1) Under the term "occlusion of gases in metals" there have been included such widely differing phenomena as solution, the formation of definite compounds which may dissociate when the conditions are changed, and gaseous products formed as the result of reactions between non-gaseous substances in solution in the liquid metal which had undergone changes in concentration, and thus were no longer in equilibrium, during the consolidation of the metallic mass. (2) The gaseous constituents of the metals used for constructional purposes affect their properties more profoundly than is generally admitted. (3) As all of the metals used for industrial purposes contain gases as constituents, and as all the more complete investigations of the common metals have been made on specimens containing such gases, it follows that we have no knowledge of the properties which the pure metals or alloys would possess if they could be produced, and such data as are available can only refer to metals or their alloys with an unknown quantity of gases as important constituents.

Dr. Walter Rosenhain said the suggestion that the solubility of certain molten metals increased with rising temperature was a startling one, and could not be accepted as a matter of course. A great many of the mechanical properties of metal were intimately bound up with the precise physical features. For instance, a small percentage of bismuth would render the mass of the metal brittle, whilst the individuals were perfectly ductile. That was explained by the presence of certain films of oxide, which were carriers of the dissolved gas and rendered the crystal boundaries weak. The fact that this amorphous or undercooled liquid played a part in the relationship of gases to metals was well established by experimental evidence.

Sir Robert Hadfield called attention to two ingots of steel which he had brought with him. They both contained 41½ lbs. of steel, and one contained 0.2 per cent. aluminium, which was practically mild steel. There was a difference of 4 or 5 inches in the length of the two ingots, due simply to blowholes. That was the type of thing they had to be content with in the early days. As regards the effect of occluded gases, he had some specimens of pure nickel, which, if heated in an

ordinary fire quickly, remained beautifully tough and could be doubled eight or nine times backwards and forwards on themselves, whilst if they were heated in a flame with sulphur they became so brittle that they could be broken in the hand.

DR. W. H. HATFIELD thought that many of those present, not being steel metallurgists, might be under a misapprehension from the phraseology used in Mr. Johns' Paper, which said that steel containing hydrogen was brittle. The fact was that all good steel contained hydrogen, and he presumed Mr. Johns meant that when a steel was in contact with acids and there was galvanic action, a certain amount of hydrogen was formed, which was an entirely different matter. With regard to the embrittling action, it might easily be that the acid had eaten in at the crystal boundaries and produced a number of minute notches, which would certainly give the steel quite the characteristics of brittleness. With regard to the author's conclusion that we know little of the properties of pure metals, he could only say that if the records of investigations carried out in this country and on the Continent and in America were searched they would be found to contain a volume of evidence concerning the actual amounts of these gases present in steel. In steel 0.003 or 0.005 per cent. hydrogen would give quite a considerable volume of material for analyses. With regard to the specimens of blown steel which Sir Robert Hadfield had shown, they were all aware that a percentage of silicon, manganese or aluminium had a pronounced influence on the retention of gases in steel in freezing. He would rather look upon it that instead of these elements preventing the occlusion of gases they assisted in the retention of them in the steel. He remembered one heat from which 50 ingots were poured. The first ingots were perfectly sound and free from blowholes, the last ingots were badly blown, whilst the remainder, in point of perfection were halfway between the other two. That result, he believed, was explained by the actual casting temperature.

GASES OCCLUDED IN STEEL.

By THOMAS BAKER, D.Sc.

It is well known that iron and steel are capable of holding in solution or otherwise considerable quantities of gas, and that these are often far from negligible. Many investigators have attacked the problem with the object of ascertaining the composition and volume of these gases and their effect on the physical properties of the metal, but little is known on this beyond the part they play in the production of blow-holes, and in a peculiar kind of brittleness which is developed by pickling. Some years ago the author carried out an investigation with the above-mentioned object, and also to discover the relation, if any exists, between the temperature of evolution of the gas and the critical points of the steel. For this purpose two crucible steel ingots, about 6 cm. sq., were prepared in such a way that whilst one was free from blow-holes the other contained as many as possible. In additon to this there were also obtained some samples of dead soft steel, such as is employed in the manufacture of tinplates. The chemical analyses of these three samples are given in Table I. The solid ingot contained also 0.033 Al.

TABLE I.

—	C.	Sil.	Mn.	S.	P.	F_2.
Solid ingot	0.90	0.088	0.006	0.023	0.010	99.01
Ingot with blow-holes	0.81	0.080	0.050	0.028	0.019	98.84
Soft steel ingot ..	0.13	0.011	0.370	0.053	0.075	99.36

The apparatus employed for the extraction of the gases consisted of a porcelain tube glazed internally and externally, and closed at each end by rubber stoppers. Through one of these passed a glass tube, making connection with a Torpler mercury pump, and through the other two glass tubes into which the leads from the thermo-couple were fused. An electric resistance furnace was employed to heat the tube, and, in order to prevent undue heating of the rubber stoppers, the ends of the tube were water-cooled. The temperatures were determined by a thermo-couple used in connection with a millivoltmeter. Before starting an actual experiment, it was thought advisable to run a blank; the pump failed to extract anything out of the tube. It was next heated for nine periods of eight hours each to a temperature of about 1,000 deg. C. and exhausted at the end of every third period. The composition and volume of the gases obtained in these experiments are embodied in Table II. No correction has been made for these gases in the appended results on the gases obtained from the various samples of steel.

TABLE II.

—	Volume in c.c.	CO_2.	H_2.	CO.	CH_4.	N_2.
First period.. ..	0.84	15.48	40.00	—	19.05	25.47
Second period ..	1.15	18.25	52.20	11.22	5.48	12.78
Third period ..	1.18	4.23	73.22	13.55	5.93	3.13

It is interesting to note that Fox found that thoroughly dried oxygen, when swept through an otherwise empty red-hot porcelain tube, persistently yielded small quantities of water—3.5 mgr. during the first hour, 0.7 mgr. from the twelfth to fourteenth hours.

A piece of one of the steels, weighing about 60 grams and having a thermo-couple inserted in one end, was next placed in the tube, the latter exhausted, and the vacuum maintained for 48 hours before starting the heating of the tube. After again exhausting the tube the experiment was commenced and continued over ten days, the period of heating being 11 hours per day; and at intervals during each day the gas was collected and analysed. The volume and composition of the gases are given in the author's Table III. (not reproduced here). In the case of the steel with blow-holes, as many as possible were cut open in order to allow the gases contained in them to escape, the object being to obtain the gases from the solid portion of the steel, leaving those contained in the blow-holes for a future investigation.

Some further experiments were carried out to ascertain the effect of such operations as annealing and mechanical work on the volume and composition of the gases. A piece of the sound steel was annealed at a temperature of about 1,200 deg. C, and the gas extracted in the manner already described; no marked changes were observed in either the composition or volume of the gases. No numerical results are given for this experiment, since they are simply a repetition of those already given for the same steel in the untreated condition. In order to investigate the effect of mechanical work, an ingot from the same cast of soft steel as that already employed was rolled down from 9 in. sq. to a plate 9 in. wide by ¼ in. thick, and a piece selected from a position corresponding as nearly as possible to that of the piece from the first ingot. The results of this experiment are embodied in the author's Table IV. (not reproduced here).

In Table V. the results of all the experiments are collected. From these it appears that the composition is practically the same throughout the series, but that the volume varies considerably. In the case "sound steel" and "steel with blow-holes," the variation in quantity is easily explained, since the latter before and whilst solidifying would boil off the greater part of the gas. In the case of the "soft ingot" also which contained an outer ring of blow-holes, a smaller quantity of gas might reasonably be expected when compared with the sound steel. It is also evident that a mechanical operation such as rolling squeezes out

a very considerable portion of the gas, which in the present case amounts to about one-half.

TABLE V.

Description.	Weight of steel.	Volume of gas per grm. of steel.	Volume of gas.	Average percentage composition.				
				CO_2.	H_2	CO.	CH_4.	N_2.
	grms.	c.c.	c.c.					
Sound steel ..	69.3	1.32	91.86	1.68	52.00	45.53	0.72	0.07
Do. reheated	47.3	1.40	66.54	1.16	49.55	45.99	2.71	0.59
Steel with blow-holes.	42.1	0.66	63.20	0.88	54.56	42.36	1.73	0.47
Soft ingot ..	66.6	1.03	68.84	1.18	52.12	45.64	0.73	0.33
Bar from do.	67.7	0.53	36.25	0.91	49.08	48.12	0.11	1.77

The thermal critical points of these steels occur at the following temperatures:—

	Ac_1	Ac_2	Ac_3	Ar_1	Ar_2	Ar_3
Sound steel and steel with blow-holes		746°			693°	
Soft steel ingot and bar	722°	758°	867°	682°	760°	846°

With the hard steels hydrogen reaches a maximum rate of evolution at 600 deg., and below this temperature constitutes the greater part of the gas given off. Carbon monoxide is slowly evolved from the beginning of the experiment, and reaches its maximum rate of evolution at 688 deg., a temperature which agrees fairly well with that of the Ar_{123} point. With the soft steel hydrogen again forms the greater portion of the gas collected at temperatures up to 660 deg., and presents a maximum rate of evolution at 609 deg. It, however, differs from the hard steel in that it has a further maximum at 786 deg., the temperature at which the carbon monoxide also reaches its maximum rate of evolution. This latter temperature is about midway between the A_2 and A_3 points. Whether these gases are the ones evolved from the steel or are formed by interaction between those actually evolved is a problem that still demands solution.

BALANCED REACTIONS IN STEEL MANUFACTURE.

By ANDREW MCCANCE, D.Sc.

There is no satisfactory theory of the reactions which take place in the open-hearth furnace during the manufacture of steel. A general view presents several separate groups of facts with independent explanations which have not yet been connected, one with the other, in logical sequence. In this Paper a rough outline is put forward of these facts considered from the standpoint of physical chemistry and of well established theoretical principles, and the connection which exists between the final quality of the solid steel and the antecedent conditions during manufacture is traced with special reference to the contained gases. Though the author deals mainly with the open-hearth process, much, of course, is applicable to the other processes of steel manufacture where the general conditions are similar in principle though different in detail.

Melting.—During the melting period in the furnace the metal is in contact with a variety of gases, such as CO_2, water vapour, nitrogen, as well as unburnt oxygen and CO, with which it can react under appropriate conditions. There is one fact which guides us, however, in determining the dominant reaction from among the many complex reactions possible, and that is, that as the average temperature of melting gets lower there is greater oxidation of the scrap, and consequently more FeO in the slag. Every steel-smelter knows that with a cold heat there is a more open slag and a greater tendency to go on the boil without ore than when the charge is melted hot. In terms of slag analyses, the following are two typical cases:—(1) Cold heat, FeO 36.3, SiO_2 36.4; (2) hot heat, FeO 20.8, SiO_2 45.0. The higher the temperature is, the rate of oxidation of the iron gets less, and possible reactions may be considered in the light of this fact.

The direct oxidation of the iron by the air is ruled out of account at once, since it is known that the rate at which scale forms on an iron surface increases greatly with temperature. Direct oxidation does, of course, take place, but it is not the main cause of oxide formation, but only a secondary one.

Oxidation by CO_2 is possible in two ways:—(1) $+Fe CO_2 = FeO + CO - 2.3$ cal.; or (2) $3Fe + 4CO_2 = Fe_3O_4 + 4CO - 1.4$ cal. These are balanced reactions, of which the first has been worked out fairly fully, and the composition of the gases which are in equilibrium with iron and ferrous oxide at different (0 to 900 deg. C.) temperatures are tabulated by the author, who has also calculated what the composition would be at higher temperatures, and finds that at 1,500 deg. it would be $CO = 92.4$, and $CO_2 = 7.6$, so that if the iron was in contact with any gas containing more than 7.6 per cent. CO_2, it would be oxidised. But the burnt gases in a steel furnace contain very little CO, and consequently reaction is possible. But the higher the temperature the greater will be the difference between the gases in contact and the gases in equilibrium, so that the higher the temperature the greater the oxidation.

The action of steam on iron gives:—$3Fe + 4H_2O = Fe_3O_4 + 4H_2 + 38.5$ cal. With increasing temperature the amount of hydrogen gets less, and the same result follows from the Le Chatelier principle, so that the rate of oxidation is in accord with the slag condition as observed in practical working.

If the loss due to scaling is to be minimised, and as little of the charge as possible is to find its way into the slag as oxides, three conditions have to be observed:—(1) Melt down rapidly; (2) melt down at high temperature; (3) have a low steam content in the burnt gases. Nos. 1 and 2 give together hot and quick working. It is often held that during the melting-down period the temperature of the bath must be constant, since there is solid and liquid metal in contact; but this is only true if there is equilibrium, which never holds for steel-melting furnaces. So long as the liquid bath is growing at the expense of the solid scrap, there is a difference in temperature between them, and the quicker the rate of melting the greater must this difference be. Pyrometer observation shows, in fact, that the temperature of the liquid bath is rising steadily during the melting period. The presence of steam in the burnt gases arises from the combustion of the hydrogen in the producer gas together with any undecomposed steam which has passed through the producer. The composition of the gas has therefore a direct bearing on the working of the furnace and on the loss of metal due to scaling. As a result of this reaction the steel has an opportunity of absorbing hydrogen.

Boiling Period.—After melting, the liquid bath has a covering of slag containing FeO and other oxides, together with silica. Independently of how these constituents are combined one with the other, the slag can be regarded as an impure solution of ferrous oxide in silica. The addition of iron ore increases the strength of this FeO solution, and since there is no contrary evidence, it must be inferred that iron oxide so added cannot act on the steel bath without first going into solution in the slag. After Si and Mn have been removed, the carbon is attacked according to the equation:—$FeO + C = CO + Fe$.

The FeO is derived from the slag, but the reaction is by no means confined to the surface layers of metal, but takes place equally throughout the whole mass of liquid. If the slag is scraped off during the boiling period the metal still goes on boiling vigorously, and can do so for a considerable time, although there are only traces of slag in contact with the steel. Clean pieces of Swedish charcoal iron containing 0.16 per cent. carbon lose all their carbon when melted in a

magnesia crucible in an electric vacuum furnace. When a local area in the bottom of an open-hearth furnace gets bad, the boil takes place much more vigorously over that area than elsewhere, and the slag may be projected some distance above the general level through the energetic action. Such facts point to the CO being liberated simultaneously throughout the mass of metal, and since the carbon is in solution, it entails that the FeO must also be in solution in the steel. On this assumption the FeO is divided between two solvents, the slag and the steel, and the application of the partition law to such a system indicates that the concentration of the FeO in the steel must bear a constant ratio to that of the slag if the molecular condition of both solutions be the same. If FeO in the steel be removed from solution, then more FeO will pass from the slag into the steel, until a balance is once more obtained, and if the FeO be continuously removed, then a continuous flow of FeO will come from the slag and will endeavour to replace the loss. If no addition of FeO be made to the slag (in the form of iron ore), then the percentage content will fall continuously.

The mechanism of the carbon reduction in the open-hearth process can now be understood, for as the ore is added to the slag it dissolves as FeO, which is transferred in solution to the bath, and reduced by the carbon there with the production of CO. The reaction will follow the laws of chemical kinetics. The carbon monoxide which is first given off dissolves in the steel, but whenever the steel becomes saturated the excess gas will escape into the air. This is the commencement of the boil. The steel from this moment is therefore saturated with gas. It is to be remembered at this stage that this will only be true if no external addition is made to the FeO after the reaction starts—that is, if no ore is added to the charge after the boil commences.

As the carbon in the bath gets less, the rate at which it is being reduced also gets less, until it ultimately becomes of the same order of magnitude as the rate of the reverse reaction brought about by the presence of the CO. When it becomes equal to the latter, then equilibrium is established, and no further carbon is oxidised. How far the attainment of equilibrium is possible in a melting-furnace is a difficult question to decide. The carbon, for one thing, is never constant, but is always dropping slowly; and the time element in practical working necessitates the adoption of other means for controlling the oxides in solution. But the conditions, however they may vary, are always trying to approach equilibrium, and alterations in the external conditions will have the same effect whether it is attained or not. The lower the carbon in the steel at the final stage, other things being equal, the higher the amount of FeO and vice versa, which accounts for the fact that mild steels are more difficult to deoxidise than higher carbon steels made under the same conditions.

Supposing lime is added to a slag which is in equilibrium with the metal underneath, then the FeO concentration of the slag is reduced and the metal is no longer in equilibrium, but contains excess FeO which will act on the carbon available until equilibrium is once more attained. For this reason CaO can replace ore with advantage towards the end of the boil, but it is obvious that this action cannot take place at the beginning of the boil, since the effect would then be directly opposite and it would retard oxidation. Any diluent, such as manganese ore, magnesia, etc., would act exactly in the same manner.

The influence of temperature is very important, and in the author's opinion it is the one method of control which is neglected in practical steel-making.

Reduction of Silicon.—With a highly siliceous slag in contact with iron and carbon, reduction of the silica may take place in two possible ways, and in both an increase in temperature will lead to a greater reduction and the formation of more silicon. From the results of a large number of estimations the author has found that in acid open-hearth working the reduction of silicon during the finishing stages, when the carbon is in the region of 0.15 to 0.20 per cent., is practically negligible. It is within the limits of chemical error. In acid electric-furnace work, on the other hand, it is quite appreciable, and it is possible to reduce 0.2/0.3 per cent. direct from the slag. In crucible melting, the killing of the melt results from the reduction of the silica of the clay pot, but crucible charges are usually high in carbon, and it is much more difficult to kill low carbon charges in this manner. The experiments of MacWilliam and Hatfield showed that this reduction may be brought about in open-hearth furnaces, but it is noticeable in their figures that when reduction takes place the carbon is about 0.40 per cent. It is fairly evident, therefore, that it is the carbon which reduces the silica and not the iron. Manganese behaves similarly, and need not be considered separately.

Carbon Monoxide.—The presence of CO in solution in iron entails a further reaction with the FeO, a reaction which has been studied over a considerable range by Baur and Glässner for solid Fe and FeO. Their results, however, will not enable us to arrive at quantitative conclusions regarding the equilibrium of the same materials when they are in a state of solution. Qualitative deductions in accordance with experimental facts can, however, be made. This equilibrium is independent of pressure, and the ratio of CO to CO_2 under reduced pressure is therefore constant (8.3 to 8.8 per cent. in three cases out of four). A lowering of the temperature of working greatly decreases the ratio. Thus in cast iron at a casting temperature of 1,428 deg. it is 30.2; at 1,348 deg. 13.7; and at 1,264 deg. 7.2. The bearing which this has will be considered in the next section.

Formation of Blow-holes.—It is a general law that the solubility of gases in liquids increases as the temperature is lowered, but at the freezing-point the solubility is much less in the solid than in the liquid state. As a result, all gases will show strongly the effects of primary segregation—that is, the concentration of the solution in the last portions to solidify. If during the progress of this concentration the limit of solubility is reached, then the excess gas will escape and blow-holes will be formed. At the finishing stages in the open-hearth furnace, as previously explained, the steel is saturated with CO and the amount of gas will depend only on the temperature. If this is constant, then all steels will start with the same amount of gas in solution. Starting, then, with a quantity of liquid steel containing CO and CO_2, and neglecting for the moment all other reactions except that with the FeO, cooling will result in more CO_2 being formed at the expense of the CO. But the steel in the solid state may have a very limited solubility for CO_2, and if this be exceeded blow-holes will be formed at the instant of solidification. The formation of blow-holes not only depends on the quantity of dissolved gas but also on the variety of gas. No attention has hitherto been paid to this possibility, and to explain all the peculiarities in the relations between these gases and steel it is only necessary to assume that steel in the solid state has a much greater solubility for CO than for CO_2.

When equilibrium is established and there is much ferrous oxide in solution, the ratio of CO_2 to CO will be correspondingly great, and when the steel solidifies, if the amount of CO_2 is greater than the metal can hold in the dissolved state, blow-holes will be formed. If, on the other hand, the ferrous oxide be removed, the amount of CO_2 will shrink until the proper ratio is reached, and on solidification the saturation limit may never be attained. It is important to note that the total volume of gas may remain quite unaltered by the reduction of the FeO, so long as direct reduction of the gases does not take place. This accords well with the experimentally determined volumes of gas by different observers. It may.

however, be taken as proved that deoxidation does not necessarily mean the diminution of the total gas in solution.

Estimation of Gases in Steel.—In steel thus the gas content in the solid state will be proportional to the gas content in the liquid solution, but the determination of the exact composition and quantity of this gas presents grave practical difficulties. Two methods only have been used so far—the extraction of the gas by heating the sample in a vacuum and the fusing of the sample in a vacuum with tin and antimony, which have practically no dissolved gas themselves. In the first method any gas which is evolved, and does not possess the composition necessary for equilibrium for the temperature of the experiment, will tend to react with the steel until it does possess that composition. Thus the composition found must have been modified in a wholly indeterminate manner by reaction taking place at a lower temperature. The sum of the volumes of CO_2 and CO, however, gives the exact volume of the mixed gases at the temperature of solidification. The composition may not be the same.

With regard to the second method, the carbon contained in the steel is insoluble in the alloy, and floats to the surface, where it remains, at the same time reducing the CO_2. The reaction not only varies with the temperature, but also with the pressure of the gases, so that the results obtained only give the volume of the gas originally contained exactly, when expressed as CO_2 equivalent. That is, the volume of CO_2 plus $\frac{1}{2}$ (volume of CO) gives exactly the volume of mixed gases originally contained by the steel.

How far the composition is altered depends on the rate of evolution, so that the effect is merely to mask the differences in composition by an uncertain amount. Qualitative deductions can, however, still be drawn from the results, and it is the object of this Paper to show how such deductions give an insight into the complex conditions existing in liquid steel during manufacture.

MR. C. R. DARLING said that electric welding had now become a matter of great importance, especially in connection with shipbuilding and repair, and it was being taken up with very great diligence both in America and here. For some time in America there had been in existence an Electric Welding Research Committee, which contained 80 members, and it had made great progress. Recently a corresponding Committee had been formed in this country, but it had not yet had time to make corresponding progress. There were one or two things which had transpired in the work of the American Committee which showed that the absorption of gases had a great deal to do with electric welding. If they took two plates, bevelled the edges, and connected them to the positive terminal of a dynamo, and used as the negative an iron rod which had been pickled in acid, a weld was obtained which it was very difficult to make mechanically strong. On the other hand, if the same iron rod was treated with an alkali, a perfectly sound weld was obtained. What the pickling of the rod had done he could not say, but whatever it was the property went right through the arc and affected the weld.

DR. HATFIELD said he did not remember ever seeing cast iron which contained blowholes due to occluded gases if the content of silicon was over 0.3 or 0.4 per cent., and it was usually higher than that. Blowholes in cast iron were almost invariably due to what the foundryman called the "drop of air," *i.e.*, the mould had not been made properly, or it was damp.

SIR ROBERT HADFIELD called attention to a drawing of a hydraulic cylinder which was made in quantities for Indian cotton mills many years ago by his father. These cylinders were made at Manchester, and to all appearances were sound, yet the moment the pressure was put upon them in the cotton mills they failed to retain it. Subsequent investigation showed that they were made of steel containing 1 per cent. of carbon; probably the founder thought it was easier to put in 1 per cent. than 0.3 per cent. The result was that the carbon was precipitated in the form of graphite, and although there was a beautiful-looking fracture, the graphite was there to the extent of 0.3 or 0.4 per cent. out of the 1 per cent. of carbon, and the result was that as soon as the high pressure was exerted the cylinders failed to stand it.

"F.T.J." Bookshelf.

Liquid Steel: Its Manufacture and Cost.—By DAVID CARNEGIE, assisted by Sidney C. Gladwyn.—London: Longmans, Green & Company, 39, Paternoster Row, E.C.4. (30s. net.)

In preparing this treatise the author has attempted, with the help of Mr. Gladwyn, to set forth and compare the various items of cost in the different commercial processes of steel manufacture. The standard text-books known to him all deal in some measure with the cost of steel-making, but no attempt has hitherto been made to compare systematically the costs of the leading steel-making processes having in view their metallurgical and engineering significance. It is his belief as the outcome of several years' experience in the management of modern steel works (the shell factory in Woolwich Arsenal, and two of the leading Sheffield steel plants among them), that the facts published in his book will be welcomed by all interested in the efficient equipment and control of steel works. Information and data of practical use to steel makers generally are given, including:—(1) The analyses and costs of iron ores, various grades of pig-iron, refractory materials, fluxes, ferro-alloys, and fuels. (2) The composition of charges for different classes of steel, with particulars of the finishing additions required. (3) Details of construction, lay-out, and costs of steel plants, including, of course, furnaces. (4) Methods of assembling steel works costs and details concerning the value of labour and the costs of living in various industrial countries. The importance of teaching students the money value of materials both in their raw and manufactured states, besides their physical and chemical values, is being more and more recognised, and from this combined point of view the hints and information given by the author and his helper will be of great practical value to the student when he passes from the lecture room to the laboratory and works.

Raw materials are dealt with first, then, in turn, the crucible process, the Bessemer process (both acid and basic), and the open-hearth process. A stay in Canada has enabled the author to add in Part IV., dealing with the electric process, a chapter on the development of electric steel manufacture in Canada to this, the second edition. There are ten plates, and in the text 252 illustrations. A full index enhances the value of the volume as a book of reference.

Part I., dealing with the crucible process, includes chapters on American practice and on tool steels; the one devoted to the Bessemer process (Part II.) has chapters on modern, both bottom-blown and surface-blown, converter plants for steel foundries, and one on converted plants for small foundries, including "baby" or "petty" converter plants, and the Stock oil-fired converter; while Part III. (acid and basic open-hearth process), includes chapters on the Talbot continuous process, and on the duplex (converter and open-hearth, and open-hearth and electric furnace) and triplex (all three combined) processes. Part IV. we have already noticed. Finally, in Part V. (Costs and Labour) the author compares the costs of liquid steels (1) produced by the same process, and (2) by different processes, and goes into the highly important subjects of (1) book-keeping of costs and (2) labour costs in steel-making.

The first edition of the book was published before the war, and the student will find some information about German pre-war steel-making practice also.

Wearing and Anti-Frictional Qualities of Cast Iron.*

By J. E. Hurst (Acton).

Cast iron possesses unique and invaluable properties when used for the moving parts of machinery. In the construction of the wearing parts of machine tools and textile machinery it has been found by long experience that cast iron has no superior. Similarly in the construction of engine cylinders, particularly internal combustion engine cylinders, in spite of its many disadvantages, cast iron is still acknowledged to be the best material from the point of view of wearing and general running properties.

Wearing of Cast Iron.—Throughout this investigation wear will be defined as the loss in weight sustained by a substance when subjected to rubbing by another substance, over a given period of time, at a given speed, and under given pressure of contact. In this particular investigation the subject will, however, be strictly limited to those instances in which wear is brought about by the mutual rubbing of cast iron by cast iron under reciprocating sliding contact.

In some recent investigations by the author on the microstructure of worn gas-engine cylinder liner surfaces, it has been shown for the most part that wear in grey cast iron is brought about by a process of surface disintegration. The surfaces of worn cast-iron cylinder specimens can be seen, on examination, to be covered with numerous holes, the result of actual detachment of the crystal grains composing the surface. In a measure, wear of this nature would naturally be expected in such a material as cast iron, in view of its characteristic composite nature and intercrystalline brittleness. On the other hand, on practical grounds we are led to the conclusion that the rate of wear is not a simple function of surface disintegration alone. The plastic deformation of the constituent grains of the surface under the influence of the stresses produced undoubtedly plays a great part in modifying the extent of the wear.

When cast iron moving parts of machinery have been in use for a length of time, they acquire a glazed appearance, trouble with "galling" or "seizing" is practically eliminated, and the rate of wear would appear to diminish. Dealing with friction clutches, it has been stated by Mr. W. C. Gass that the coefficient of friction varies greatly with the state of the surfaces, and after the surfaces become glazed with use, it drops away quickly. Practical experience in connection with internal combustion engine pistons and cylinders confirms this conclusion. The cylinder walls in high-speed engines which have been running for a considerable period become glazed, harder, and considerably more difficult to file. It would appear that the object of some of the large continental gas-engine manufacturers in subjecting cylinders to a period of running in their engines previous to putting them in work, is in part to produce this glazed surface. There is no doubt that this glazy appearance produced on cast-iron surfaces after subjection to rubbing is due in some measure to the plastic deformation of the surface grains. Many instances have been met in connection with internal combustion engine cylinders in which layers of material can be distinctly seen to have flowed over the surface, filling up the hollows resulting from machine tool marking. These layers can be removed by careful polishing and etching and the underlying machine tool marks thus revealed. The unetched surfaces of worn engine cylinders under the microscope very frequently present a very finely divided granular structure in which the hard particles of phosphide eutectic can be seen standing in relief. It is believed that this granular type structure is the result of plastic deformation of the surface grains.

In the particular case of engine cylinders, the debris become suspended in the film of lubricant, and in this condition most probably act as a polishing agent whereby the relief polishing effect observed in the microexamination of worn liner surfaces is brought about. Many cases of galling or seizure of the piston and the liner are known which cannot be easily accounted for by the tightness of the piston, or alignment of the engine, or any other mechanical agency. Such seizures frequently take place shortly after the cylinder or liner has been put in work, and are for the most part encountered in those cylinders consisting of very open-grained cast irons. The amount of debris produced is so large that the friction set up as a result of its presence develops momentarily sufficient local heat to melt the debris. On taking out the piston, the layer of material pasted on to the side of the liner can be plainly seen and is perfectly glass hard.

An interesting example of the "rolling in" of debris into the wearing surface of cast iron has been recently met with. This is the case of a face-plate of a lathe used for the turning of extra heavy flywheels upwards of 12 tons in weight. The larger portion of the load was taken up by two hardened steel rollers. The whole of the circumferential face, which was about 12 in. in width, was originally machined. After being in use for over eight years, a band round this face was worn some 3-16 in. deep, the width of the rollers. The whole of the surface of this band presented a distinctly disintegrated appearance, and was found to be covered with flakes of material distinctly having the appearance of having been rolled in. The flakes could easily be detached. Some of them were collected and analysed, with the following results:—Combined carbon, nil; graphite, 3.49; total carbon, 3.48, by combustion; silicon, 2.66; manganese, 0.99; phosphorus, 0.79 per cent. They were undoubtedly debris resulting from wear and had been actually rolled into the surface. The author has no chemical analysis of the actual plate, but from the pig-irons used in the mixture it is certain that the phosphorus content is higher than that found in the flakes themselves, and is about 1 per cent.

Surface Finish.—It will be readily appreciated that the state of the surface finish will exert a great influence in determining the initial rate of wear of the cylinder. A roughly finished liner wears initially very rapidly, and there must be many cases of seizure of gas-engines which, if thoroughly investigated, could be largely attributed to the rapid production of debris as a result of the rapid initial wear due to a rough-machined surface. In the second place, cast iron, owing to its relatively brittle nature, is far more sensitive to the stresses set up during machining than most metals. Consequently with rough and severe machining the surface of cast iron becomes badly disintegrated and distorted and full of crystalline cracks, which may extend to a considerable distance into the iron, far below the actual surface. This will undoubtedly tend to increase the wear by surface disintegration owing to the partial loosening of the crystal grains. It is probably due in a large measure to these reasons that an internally ground surface is far more satisfactory than an ordinary machined surface on cast iron Diesel engine liners. It will readily be appreciated also that the extent of the damage done to surfaces as a result of machining will vary in different cast irons, and will be

* Abstract of "Preliminary Note" to a Carnegie Scholarship Memoir.

largely a function of the tensile strength. It is, therefore, of paramount importance in the study of wearing phenomena in cast iron to ensure a standard form of "surface finish" on all specimens investigated.

Mechanical Properties.—In actual practice it is frequently difficult to correlate the various mechanical properties with the wearing properties. Cast iron, it must be remembered, is a conglomeration of constituents of widely varying mechanical properties, separated at their boundaries by graphite plates. On this account, consequently, the mechanical properties of the alloys, when considered as a whole, bear no definite relation to those of even the majority of its constituent grains, and are also very sensitive to slight variations in structural arrangement. It is legitimate to conclude that the character of the constituent grains of the cast iron exerts considerable influence on the wearing properties, and it will therefore be obvious that the comparison of mechanical properties alone, unaccompanied by some idea of the structural arrangement, is unsatisfactory. In this respect cast iron is different from other alloys. An attempt at determining the relation between the mechanical properties of cast iron and wear is that contained in a pamphlet issued by Messrs. Ludwig Loewe & Company, Limited. In these experiments wear was determined as the loss in weight sustained by a specimen of cast iron on rubbing at a given speed and under a given load in contact with a hardened steel die. The loss in weight sustained after rubbing for a given period of time was plotted against the tensile strength, and a perfectly smooth curve obtained. So far as the author is aware, however, no data were included in these experiments respecting the chemical composition and microstructure of the specimens tested. The period over which the rubbing took place, and the influence of debris resulting from the surface disintegration, are also important factors, and it would not appear that any special attempt was made in this research to determine the influence of these factors. The rate of wear, as measured by the slope of the curve, was much greater and faster with the lower tensile strength irons. The extent of wear in this case was very large, amounting to 70 per cent. of the total weight of the specimen.

Hardness and Wear.—The Brinell hardness numeral bears no simple relation to the wearing qualities of engine cylinders, and hence it is little guide to the nature of these qualities. Cast irons having the same hardness numeral frequently wear at widely different rates, and softer cast irons frequently wear longer and better than harder ones, and *vice versa*, under identical industrial conditions. The problem of the relation of the Brinell hardness numeral to wear in the case of cast iron is rendered considerably more complex by the uncertain relation of the numeral to both the chemical constitution and the other mechanical properties of the metal. Apart from the chemical constitution, the Brinell hardness is dependent on the size and distribution of the structural components of the iron, which may vary considerably in any given alloy within wide limits. The size and distribution of the structural components are dependent on a number of factors, amongst which the casting temperature and the rate of cooling are of primary importance.

Again, the chemical constitution may vary considerably without any appreciable effect on the hardness numeral. For example, it is possible to have two cast irons of practically the same hardness numeral varying considerably in, say, phosphorus or manganese. The wearing properties of these irons will vary considerably. The influence of casting temperature is of considerable importance in a research of this nature. Twelve samples were cast under strictly comparable conditions from cupola iron, and the variation in Brinell hardness observed was strking. The average hardness of a low-phosphorus sample was considerably below that of the high-phosphorus samples, yet with a sufficiently high casting temperature the low-phosphorus sample was rendered as high as that of the hardest samples. It is legitimate to conclude from this that the variation in the Brinell figure is largely caused by variations in the structural arrangement due to the influence of casting temperature.

Chemical Constitution.—So far as the author is aware, there has been no organised research published on the influence of varying amounts of the constituents present on the behaviour of cast iron under wear. The investigation of this portion of the subject is one of the main objects of the present research.

Microstructure.—It may also be anticipated that the influence of chemical composition on the wearing properties of cast iron will be indirectly connected with the microstructure. In any case, particularly in work of this nature, the chemical and structural consitution cannot be considered separately.

Anti-Frictional Qualities.—It is a well-known fact that cast iron behaves at least as satisfactorily as, if not more so than, most other metals or alloys from the point of view of over-heating and seizing when employed in any capacity in which it has to resist wear. Cast iron for this reason can be legitimately classed alongside the so-called anti-frictional or bearing metals. In fact, lineshaft bearings are nowadays frequently made of ordinary grey cast iron, and are being used with far more satisfactory results than any of the usual anti-frictional metals. Experience with anti-frictional alloys has shown that such an alloy should consist of at least two constituents of widely different physical properties embedded in each other. The soft constituent confers upon the alloy the necessary degree of plasticity, whilst the presence of the hard constituent raises the critical pressure which produces the sudden increase in the coefficient of friction. When in actual use the surface of these alloys is worn in such a manner as to produce a surface of an irregular contour, the harder portions standing in relief. The minute depressions over the surface of the bearing metal in actual use can be considered to serve as minute reservoirs which preserve an effective distribution of lubricant over the whole of the bearing surface. It seems probable that the anti-frictional properties of cast iron may in large measure be due to the structural character of the iron. Cast iron contains the necessary hard constituents embedded in a softer matrix which under certain conditions may exhibit definite cellular arrangements which are undoubtedly in a large measure responsible for the excellent anti-frictional properties.

It is maintained by many that the lubricating qualities of the free graphite present in cast iron are likewise largely responsible for the excellence of these qualities. According to Acheson, it has been found that 0.35 per cent. of colloidal graphite properly diffused is sufficient to confer exceptional lubricating qualities in the oil. Even though such a small quantity of graphite be responsible for a marked increase in the excellence of the lubricating qualities of oil, it is difficult to conceive how the small amount of graphite in the superficial layers of cast-iron cylinders can account for the excellence of their anti-frictional properties over the long period some of these cylinders are in use. It is undoubted that the glazy surfaces produced on cast iron after subjection to wear also influence in a large measure the anti-frictional qualities as already mentioned.

Certain manufacturers using cast iron for lineshaft bearings subject it to a preliminary annealing treatment. Manufacturers of textile machinery also anneal all cast-iron spindles. It is claimed that by this means the wearing and anti-frictional qualities are both improved, although in the case of textile machinery, machining considerations enter largely into the question. It is by no means obvious why annealing before use should improve the cast iron from this particular point of view.

Objects of Investigation.—The main object of the present investigation, in the first place, is to determine the extent of the influence of variations in the chemical and structural constitution on rate and extent of wear. A reciprocating machine is in course of construction for the purpose of carrying out wear tests. In this machine a specimen will be subjected to the wearing

action of another specimen of the same material. The chief reasons for choosing a reciprocating motion are:—(1) It more nearly approximates the industrial conditions obtaining in an engine cylinder. (2) It allows of the employment of flat-faced specimens, which are more convenient for microscopic examination.

A second machine is also being constructed in which a small specimen will be pressed against a standard cast iron rotating disc by a definite load.

A complete series of bars have been prepared, the compositions of which have been so arranged as to obtain a complete series of alloys varying in each constituent over the ranges commonly met with in industrial practice. Special precautions were taken during the casting to ensure as far as possible strict comparability. The complete chemical analyses, mechanical tests, and micro-structural measurements of these bars are being prepared.

Magnesia Bricks.

According to a recent contribution to the "Comptes Rendus" of the Paris Academy of Sciences by Messrs. H. Le Chatelier and B. Bogitch, on the refractory properties of magnesia bricks made in the laboratory from more or less pure magnesia or commercial specimens, of the six magnesia specimens experimented on, one was an old Styrian brick of normal quality (I.) which had been baked at 1,450 deg. C. Another (II.) was a brick of recent make, from Eubea, in Greece, of great purity. Two other bricks (III. and IV.) were commercial specimens of good and medium quality respectively. Two more specimens were one of "pure" magnesia (V.) and one (VI.) made from the material of No. IV. brick respectively, the latter mixed with 3 per cent. of calcined pyrites. The last two had been made in the electric furnace. The resistance to crushing is given at 15 deg. C. (laboratory temperature) and at 1,000, 1,300, 1,500, and 1,600 degC. for No. 1, and at 15, 1,500 and 1,600 deg. C. for some of the remainder. In the case of the Styrian and Grecian bricks tests were made at frequent intervals, and two curves were plotted from the results thus obtained, which are reproduced with the Paper. The magnesia bricks showed a sudden drop in the resistance to crushing at a temperature depending on their degree of purity. In the case of the Grecian brick, the purer of the two, the rapid drop began between 1,500 and 1,600 deg. C., while the Styrian brick began to fail between 1,300 and 1,400 deg. C.

The authors' explanation of the behaviour of magnesite bricks at high temperatures is that at 1,600 deg. the magnesia begins to behave like clay—that is, it softens and gives way gradually, while silica collapses suddenly. On cooling, the disintegrated material re-coheres and regains its original hardness as soon as the magnesia has become solidified. This fact explains why in practice it has been found that magnesia bricks stand less well in furnaces than do silica bricks, although their fusing points, observed in the ordinary way without regard to resistance to crushing, may be higher than those of silica bricks, being about 2,050 deg. C. in the case of magnesia bricks, as against, say, 1,750 deg. C. for silica bricks. Pure magnesia fuses at about 2,400 deg., i.e., about 700 deg. above steel furnace temperature, but magnesia bricks are never pure, but always contain, besides silica and a little alumina, more or less oxide of iron in the form of a carbonate, which is isomorphically mixed with the carbonate of magnesia. A seventh specimen (VII.) tested by the authors was a ferro-chrome brick, a material used for isolating the silica bricks from the magnesia bricks in the furnace. The curve of the failing crushing strength of the ferro-chrome specimen with increasing temperature showed the same rapid fall as the magnesia brick curves, but the fall began at a lower temperature, at about 1,100 deg. C. The following table shows the crushing strength in lbs. per sq. in. of the seven specimens at 15 deg. (laboratory temperature) and at 1,500 and 1,600 deg. C. respectively:—

	15°.	1500°.	1600°.
Magnesia bricks.	Lbs. per sq. in	Lbs. per sq. in	Lbs. per sq. in
I. Styrian	2,062	51	26
II. Grecian	5,974	2,631	114
III. Good quality ..	5,547	over 1,280	68
IV. Medium quality ..	3,272	228	50
V. "Pure" magnesia	—	over 1,280	94
VI. No. IV. and pyrites	7,540	—	50
VII. Ferro-chrome ..	3,700	28	under 16

The difference in the strength of the Styrian and Grecian bricks at 1,500 deg. is remarkable. In respect of chemical composition, the two bricks compared as under:—

	Styrian.	Grecian.
	Per cent.	Per cent.
Magnesia	86.7	93.4
Lime	1.0	3.7
Oxide of iron (F_2O_3)	6.0	0.5
Alumina	0.6	0.2
Silica	6.7	2.8

With regard to specimen V., the intention was to produce test pieces as pure as possible from precipitated magnesia, but on melting this in the electric furnace the lime contents and other impurities in the furnace lining began to volatilise, and contaminated the material, so that the magnesia content of the specimen was lowered to 93.7 per cent., a degree of purity closely approached by the Grecian brick.

EFFECT OF SIZE OF GROG IN FIRECLAY BODIES.—According to Mr. F. A. Kirkpatrick, in practice the cementing action of fine-grained bond clays takes place at temperatures from zero to that of the electric arc, depending upon the nature of the process, and is due to many different chemical reactions. In the author's experiments the bonding power of mixtures composed of raw clay and calcined clay was determined after these bodies had been heated to 110 deg. C. and to 1,250 and 1,300 deg. C. The general rule in ceramic bodies is that strength increases with decrease of porosity. This factor may be over-ruled by others; in some cases the size of grain of the bond clay also affects the strength of the body. In regard to the grog, aside from other considerations, the following condition is necessary for highest strength:—The mixture of sizes must be such that the smaller particles fill the voids between the larger, giving maximum density. The proper proportions can only be determined accurately by experiment. The strongest raw bodies were those in the author's Series 4 and 7. In the former they had the following limits of grog composition: 25 to 66⅔ per cent., 20 to 40 grog; 0 to 25 per cent., 40 to 80 grog; and 33⅓ to 66⅔ per cent., 80 to dust grog. In Series 7 the strongest bodies were those containing the greatest percentage of 80 to dust grog. The control of strength in the burned state was not at all difficult. For all bodies used, the modulus of rupture was found to increase with increase of surface factor. The relation was represented by straight lines except that at the lower ends of some of those representing large-sized grog they finished off in curves of parabolic form. The rate of increase of strength increased with the temperature of burning. The porosity at Cone 12 varied much the same as in the raw bodies and had little relation to strength. The strongest bodies were those in Series 4 (20 to dust grog). No relation was found between strength in the raw state and in the burned state. In the quenching tests from 600 and 1,000 deg. C., mixtures of the larger sizes of grog gave the more resistant bodies.

British Foundrymen's Association.

The Apprentice Question.

BIRMINGHAM BRANCH PRESIDENTIAL ADDRESS.

At the opening meeting of the Session of the Birmingham Branch of the British Foundrymen's Association on October 26, Mr. J. J. Howell delivered his Presidential address. Mr. Ernest Wright (Vice-President) presided.

MR. HOWELL'S address was as follows :—

Among the many great problems awaiting solution surely the necessity of providing the requisite number of capable craftsmen to carry on in future the industry in which we are all so closely interested must claim our primary attention. It is emphatically a question calling for the best intelligence which the "B.F.A." can furnish. Much of the preliminary foundation work has been done by a special committee specially formed by our Association to deal with this matter. But this Committee has suspended its labours owing to the war. I would, however, very strongly urge that the Committee should resume its labours at the point where they were suspended, and should as early as possible present to the Association as a whole their proposals in concrete form suitable for practical application.

One of the gravest problems confronting the employer to-day is that of obtaining a sufficient number of competent workers. The difficulty is by no means confined to the foundry trade, or even to British industry—it is world wide. So great was the concern of America upon this question that in 1915 the various industrial Associations met in conference to discuss in detail, and, if possible, to discover a solution of this vexed question. A lengthy abstract of their proceedings was published in the "Foundry Trade Journal" of October, 1916, and to this abstract I will make reference somewhat later.

It is a matter of common knowledge that the material out of which the foundry has to build craftsmen is generally of a very low order. Usually the best type of boy is not attracted to the foundry trade. The foundryman in the past has been largely responsible for this; he has been satisfied to surrender the pride of place to other branches of engineering. But, happily, this state of things is passing away. The moulder of to-day is more conscious of the important part he plays in engineering and is asserting himself accordingly. The definition of the moulder's art at one time was that he "kicked a hole in sand and poured iron into it." This was never true, and to-day it is less true than ever. The demand for brains in the craft of the moulder is to-day greater than ever before; and this demand will increase as time goes on, because the tendency of present-day design is to save costly machining, and castings which were formerly made in several pieces are now being made in one piece. This often results in a most complicated piece, calling for an amount of initiative and careful handling that dwarfs the efforts of any other department of engineering. It is the training of craftsmen to handle such work as this that we have in mind now. If this pride in one's work can be fostered and made to grow we shall hear less of the undesirable boy finding his way into the foundry.

A more lively interest in the boys in the foundry must be shown than has been the case in the past. The boys must be educated, and their education must proceed along carefully thought-out lines and with a definite object in view. What is needed is a broad industrial education which will give the youth the power to see beyond the immediate task, the power to see the relation of his skill and the results of his craft to the success of himself and his fellow workmen; the power to realise that to become a good craftsman is to become a national asset. His education must be such as will make him think and be ready to take the initiative. For this, he must have some knowledge of the materials he is using, of the method of their production and their cost, and ideas as to the organisation of modern industry. All this, and more, should be knowledge within easy reach of the foundry apprentice.

But how is this to be attained? In the answer to this question is comprised the whole solution. Many are the suggestions that have been put forward. Personally, I do not think the solution is in the night school. Boys and youths who have worked all day in the foundry will never take kindly to night school; and, if they did, their mental condition would be such that the teaching would have little or no good results. Many will be inclined to remark that the boys are not too tired to play football, cricket, etc. Quite right, too; they ought not to be too tired, for such exercise is necessary to their physical development, which is as important as the development of the mind. If we are to get the best results, if we are to have a more intelligent generation of craftsmen, we shall have to impart that knowledge and cultivate that intelligence in afternoon classes. Employers generally are sympathetic towards some such scheme. For it is realised more to-day than ever that something must be done, and done quickly, to attract more boys into the foundry, or the trade will suffer a severe set-back.

We believe that this Association has done wonderful things towards establishing the foundry trade in its rightful position among the engineering trades, and that by its means we are securing that respect and consideration which is our lawful due. But, much as this Association has done, it can do much more. It must permeate the whole trade with a pride in its work, with the pride that is felt by one who knows himself to be the producer of a work of art. This is only possible of achievement by means of education. Therefore this Association must take the question of education most seriously. The time is ripe for it. Our education authorities are willing to help us. We have had proof of this in Birmingham. A class was started specially for youths from the foundry. But it was not so successful as it might have been, and the reason for this was that it did not have the support which was necessary for its success. Such classes, to be a real success, must have national support and the support of every city or town which has an official centre of learning. In order to bring this about, this Association, with its knowledge of the requirements of the foundry trade, should re-assemble its Apprentice Training Committee and formulate a definite curriculum. The scheme should then be submitted to the employers for their support.

The foundry employer to-day is equally concerned with us as to the future of the trade. Employers realise that foundries and the foundry trade must be made much more attractive if we are to get the right type of youth to ensure the successful conduct of the trade in the future. Because I believe this to be true, I think that if our Association would formulate a progressive curriculum, one embodying all the subjects that are necessary, the employers would grant to their young employees time during their working hours to pursue the studies which are so necessary to the well-being of the trade.

The Conference Board on Training of Apprentices, to which I referred at the beginning of my address, said :—

"To-day practically all employers, and all who

are interested in the future of our country and in good citizenship, admit the importance of the apprenticeship question. We hear a great deal about conservation of our natural resources—but how about the conservation of our *human* resources? We also hear a great deal about preparedness—but how about preparedness of the individual worker that he or she may be an economic producer, enriching our standard of civilisation rather than a mere automaton, a lever pusher, simply following the worn ruts of wasteful producers?

"It has been well said:—'It is highly important that we realise two things: first, that our most valuable resources are our people; and second, that we are wasting people more than we are wasting anything else. . . Speaking generally, one is safe in saying that no nation ever did prosper as compared with other nations except by reason of its superior conservation of the human factor in production. In view of these large facts it is reasonably safe to say that the most destructive form of waste is the waste of labour power.'

"The great mass of American youth is absorbed in industry, yet by far the larger proportion goes into industry without sufficient academic training to develop thereon the best type of citizenship or to give a firm foundation for subsequent specialised trade training. Of those who do possess the proper preliminary training, unfortunately but a small percentage is attracted to the learning of a trade. This is because the dignity of trade mastery has not been inculcated in the minds of parents and educators, although it is gratifying to record that, because of the agitation of this subject during the past few years, it is now receiving the attention of educators and parents as well as of enlightened employers.

"In his monograph, 'Education for Efficiency,' Dr. Charles W. Eliot says:—'By efficiency I mean effective power for work and service during a healthy and active life. This effective power every individual man or woman should desire and strive to become possessed of; and to the training and development of this power the education of each and every person should be directed. The efficient nation will be the nation made up by aggregation of individuals possessing this effective power; and national education will be effective in proportion as it secures in the masses the development of this power and its application in infinitely various forms to the national industries and the national service.'

"If employers will unite, through properly co-ordinated and effective apprenticeship systems, to work for this industrial efficiency by giving to their employés the opportunity 'to acquire effective power for work and service during a healthy and active life,' the dignity of a trade and the honesty of manual labour will receive new high values, and new standards of industrial ideals will be developed.

"Many employers, it should be said to their credit, are thoroughly alive to the necessity of apprenticeship training, and are doing all they can individually to awaken their fellow-employers to this industrial need. It is nevertheless a fact that most employers are giving little heed to the subject. The average employer, not from necessity but because of thoughtlessness or habit, still prefers to get workmen whom someone else has trained. When he employs one or more boys, he does so not for the purpose of making them skilled workers, but because there is a certain amount of boy work about the place which can be done cheaply by boys. There is not only a widespread indifference among employers to the proper training of young workers, but there is often a selfish objection to it. Many employers make the excuse that there is not sufficient time to teach boys the trade; consequently, they refuse to employ inexperienced young people, preferring to leave their training to others. These employers demand experienced workers, and will take no others, except that they employ boys for boy jobs, and do not give even these a proper chance for advancement, so that they either have to migrate to other places where such chance is given, or remain for ever in the 'lumper' class."

One can well understand that for a small firm employing one or two boys it is impracticable to have suitable classes at the works; only large concerns could possibly entertain such a proposal. Therefore I would suggest that when this matter is taken up seriously the present machinery of technical education be harnessed to our scheme, the authorities being asked to arrange for day classes at suitable hours for foundry apprentices. A point of great importance to any Committee dealing with this question is the lax condition of the apprenticeship system. In many works no system of apprenticeship exists at all; many boys are at work in foundries without any fixed idea of taking up foundry work as a profession. They are free to leave the foundry at any time to take up any other class of work. This state of things does present a real problem. I would suggest that it should be made possible for all boys and youths employed in foundries to join the classes if they so desire.

As to the curriculum of the classes, I certainly should not care to accept the responsibility of preparing it. Many have been the suggestions made, but none that I have read meet the requirements more fully than that of Ludwig Loewe & Company, which is as follows:—

Practical Work.—Sand Moulding: Sand cores, 9 months; loam cores, 6 months; sand moulding, 12 months; carpentry, 3 months; large sand moulding, 17 months; testing and joining, 1 month. Loam Moulding: Loam cores, 6 months; carpentry, 2 months; large loam moulding, 27 months; testing and joining, 1 month.

School Work.—Two afternoons per week—one from 2 to 6 and the other from 4 to 6—extending over the whole period of four years as follows:—

First Year.—General intelligence, two hours—the legal relations of employers and employees; the rights and duties of working men; the history of Trade Guilds; the relationship of apprentices to the Guilds; accident and sickness insurance; patents and trade-mark law; citizenship, reading and correspondence. Drawing, two hours, instruction in this subject to be specialised for foundry work. Arithmetic, two hours.

Second Year.—Workshop, two hours—Construction of a foundry; general arrangement, descriptions of cupola, machines, etc.; lighting and heating; safety appliances; hygiene; comradeship, courtesy, payment of and claims for wages. Drawing, two hours—model, specially related to foundry work. Arithmetic, two hours—Exercises in lighting and heating, transport of raw material, and costing.

Third Year.—Raw materials, two hours—materials of construction, their production, classes and properties; forging, rolling, etc.; properties and manufacture of copper, tin, zinc, etc., and their alloys. Arithmetic and geometry, two hours; drawing, two hours—model, with special reference to foundry work.

Fourth Year.—Foundry education: Description of the various foundry tools; moulding; casting; cupola practice; citizenship, one hour-constitution of State and Empire; Imperial Revenues and expenditures; the rights and duties of citizens. Drawing, two hours.

Mr. J. Horne, in a Paper on the subject a few years ago, said that this short abstract from the syllabus indicates that whilst a considerable part of the time is occupied with work directly connected with the practical side of the foundry, the most important side of the education is the development of the inculcation of the idea of citizenship and the cultivation of general intelligence. With this I am in full accord. If we are to get the best out of boys and youths they must be educated along lines such as

will widen their outlook and give them a keener conception and broader ideas of production and costs; ideas as to the organisation of industry; and ideas as to the nature and extent of the business of the country. Until this is done I feel that the British Foundrymen's Association will not have played to the full the part which it is possible for it to play.

Discussion.

The CHAIRMAN, opening the discussion said that one of the primary essentials to progress in the foundry was skilled labour, and another, which seemed almost opposed to that, was the free application of cheap power through machinery. One of the greatest changes that had come about during the past few years was specialisation, with the accompanying use of mechanical power; and this free use of machinery did not as a rule promote skill on the part of the workman, the danger being that the operative might become what had been sometimes called a mere automaton, having no more to do with the operation than the pulling of certain levers—in fact, one often heard it said, "If they will only let the machine alone it will do the work itself." As foundrymen they could say that there was no trade in which skill would be more called for in future than in their industry, and while it was quite true that there were many large concerns engaged on specialised work in which women and even girls and boys were turning out large quantities of material, it would still remain that a great deal of ironfounding must be done by skilled men.

One of the difficulties in the training of foundry apprentices arose from the fact that, while the youthful patternmakers could attend wood-working classes to learn their trade, and the turners and fitters could find plenty of well-equipped engineering workshops at the leading technical schools to learn theirs, there were few classes to which a moulder could go to learn the practical side of his work—certainly not in the Wolverhampton district. He supposed the cost of the equipment that would be necessary for the melting of the iron and the handling of the castings was one of the chief hindrances, and a good deal of courage was undoubtedly necessary if this problem were to be properly tackled. He hoped the Birmingham Branch would take this matter up and do their best to see that the training so ably recommended by their President could be effectively undertaken. It was quite true that skill in the foundry could save a great deal of unnecessary machining. As anyone who had charge of both a foundry and a machine shop knew, a great deal of time and money was wasted in discovering that castings, which looked quite sound and good, were really scrap when the skin was removed.

MR. E. H. BROUGHALL said that, as one who for the past 25 years had been handling youths in engineering works, he could agree with a great deal of what had been said. At the same time, however, he did not think that Mr. Howell had gone to the root of the trouble they were experiencing in getting efficient boys in the foundry. He felt sure that this was due, to a great extent, to the fact that the elementary education of boys was wrong. The methods of teaching in the present Council schools had time after time been proved to be wrong, but it was encouraging to know that in the near future we should probably have the methods improved of our education system. In the works with which he was connected at Coventry they did not admit any boy into the machine shops unless he was agreeable to be apprenticed. They selected, to the best of their ability, all their boys, who had to obtain a recommendation from their schoolmasters before they were engaged. The boys were then put on a six weeks' probationary period, and then put through an examination by one of the company's officials with a view to testing their general knowledge, and it was really heartbreaking to read some of the examination papers of those boys who had received recommendations from their schoolmasters. This state of affairs was not the boys' fault at all. It was the fault, the speaker thought, of the methods of teaching boys whilst at school. The question he would like Mr. Howell to thrash out more thoroughly was, why we did not get decent boys in the foundry. There was no difficulty in getting them in the machine shop. His experience was that they probably got more applicants in the machine shop than they could do with, but it was very difficult indeed to get decent boys in the foundry. At the present time he was trying a system in which he had a good deal of faith, though he feared it could not be carried out on a large scale. He had been fortunate enough to receive applications for a position in the foundry from two boys who had had a good secondary education, and who had obtained special scholarships put up by his (Mr. Broughall's) company, which gave the winners special privileges similar to those given to premium apprentices. These two youths were working in the foundry as ordinary workmen, both at the present time being engaged on core-making.

This reminded him (the speaker) of a point in which he differed entirely from the Vice-President, who suggested that the boys should be taught moulding in the technical schools. His (the speaker's view was that the boys should certainly be taught their practical work in the shop under shop conditions, and that they should be taught their theoretical work in the technical school or the university. As regards the two youths he had been speaking of, they attended Professor Turner's lectures on "Metallurgy" each Tuesday and Thursday morning, and spent some time in the University laboratory under Mr. Stansbie and it was hoped by this means they would obtain a thorough technical knowledge of foundry work. Besides this, the terms of their indentures entitled them to 12 months' instruction in the works pattern shop, together with a period in the works laboratory. It was not intended to make pattern makers or moulders or core-makers of these youths, but to bring them up as practical and technical foundrymen. Moreover, the speaker was pleased to say that both of the youths were members of the British Foundrymen's Association.

MR. F. J. COOK, referring to the Association's Apprenticeship Training Committee, of which he was a member, said that it had got so far as to set up a curriculum for a three years' course of training; but, unfortunately, the work had to be suspended immediately after the war broke out, because the members of the Committee were men holding very responsible positions in the trade, and were all engaged in the production of material required for the war. However, the Committee was not disbanded, and they had very great hopes that, in the near future, they would be able to resume their labours, and present to the trade a scheme for the training of youths. He had every confidence that the scheme would eventually stand the test of time, and produce very good results. One of the most essential things for success was that

the technical schools which were going to convey that education should be equipped with suitable staffs. At the present time he doubted if there was a school in the country with a staff capable of dealing with the matter from the foundrymen's point of view. He had no desire to belittle the capabilities of the teachers, but they had not sufficient practical experience to be able to present the instruction as it was required by foundrymen. There was, however, going to be a great change in the country, and there were plenty of foundrymen quite capable of meeting all the requirements. He need only mention that in Birmingham their own energetic Secretary (Mr. Shearman) was the leader of a class in the technical school engaged in teaching moulding and core-making. That class had been established with a view to the training of disabled soldiers, who required a new occupation after the war, and there was every hope that that class would yield very good results.

The President had laid stress upon the necessity of widening the outlook of the boy. While that was very necessary, they could not put old heads on young shoulders, and expect a boy to view matters of national importance with the same seriousness as he would a few years later. He entirely agreed as to the position of the evening class. He knew what a strain that involved. It was quite a mistake to expect a boy who had done his day's work in the foundry to give the attention necessary to make progress at school. He understood that a new system had been adopted in America, in connection with the engineering trade, which had yielded very good results, although he was unaware whether that had been applied to the foundry. It was the practice to have two sets of apprentices, one of whom worked in the engineering shop while the other was set free to go to the technical school. Under that system each boy got a week alternately in the shop and in the school. The results had been most satisfactory to those firms who had adopted the system. They had been enabled to more than treble their staff within a few years, and they attributed that very largely to the class of workmen built up under that system of education.

Another point of great importance was the assistance which could be given to the education of the boys through the sympathetic help of the foremen and managers. A sympathetic word occasionally would go a long way in encouraging the boys to give attention to their work. He had always held that institutions like that school should include on their boards of management men of standing in particular lines of business who could give some idea as to the method of training required from the practical point of view, and he gave some suggestions on those lines in his own address some years ago. That share of control was capable of being extended, and if a class were started or extended at the school or the university there were qualified men in the district who would be of very great assistance to the controlling authority in directing the lines on which education should be given.

Mr. J. Shaw pointed out that the President had not shown how they were to induce the apprentices to take on the course of study outlined. It had been suggested that different employers should subsidise apprentices for a certain length of time. Unfortunately, in the foundry trade there were too many small people to make that kind of thing possible. Undoubtedly a vital element of the British foundry trade was that it depended to a very great extent upon the small employer. It was all very well for Mr. Broughall to set forth his scheme, but his firm had a practical monopoly of trade and were making large profits. Really the whole thing depended on what the trade was prepared to do as employers, and undoubtedly the first essential was to educate the employer, who was apt to turn down with very little consideration technical and scientific study and that kind of thing. In his (Mr. Shaw's) view the best scheme that had been evolved was the one now in vogue at Falkirk. In that part of the country they believed in education, and it was to their credit that the employers there banded themselves together into an association, and they set aside one-quarter of 1 per cent. of the wages bill, and out of that fund engaged Professor Campion to teach the moulders and apprentices the technical side of their craft.

If they were prepared to sink their prejudices and their secrecies and combine to employ men well up in practical and technical matters, that would meet the case. An important aspect of the matter related to the condition of the foundry, into some of which no respectable boy would go. He had had the privilege of entering some of them, and he had seen people going about with lamps because they were entirely without daylight. Unfortunately, employers would not tackle that question, and so the boys could not be got. Something was said about night classes and night schools, which were no doubt very good, but after a lad had carried shanks all day he was not going to a night school. Obviously, a boy would not go to a night school after he was exhausted by a hard day's work in the foundry. They might say what they liked about Germany, but she was still greatly in front of us in matters of organisation and in the training of boys. This country was simply not in it. The German schools were carried on in the daytime, and by arrangement an employer ascertained how many youths he could spare, and the boys commenced work at eight o'clock in the morning, and they went through the day spending two hours in school and the remainder at their trade, so that the lads were thoroughly trained. Unfortunately, the British employer could not spare his boys to go through training like that. The system of a double set of apprentices had been in vogue in the shipbuilding trade in Wallsend for some time. But the crux of the matter lay in the fact that the employers generally did not realise the necessity of training the boys in that way. They would never do anything serious until they began by interesting the employers and convincing them of the necessity for the proper training of boys as a paying proposition.

Mr. A. R. Bartlett (Past President, London Branch) recalled the difficulties he had had in inducing boys to attend classes that had been arranged by the Educational Authorities. After much trouble a few were induced to go, but not all were willing, some of thef going merely because it gave them an outing and their fares were paid. The class only continued one year, and the only student who remained to the finish was a boy from his (Mr. Bartlett's) own shop, who was there obviously because of the persuasive power constantly brought to bear. He (the speaker) quite agreed with Mr. Shaw that the conditions of the foundry were responsible for keeping the boys outside—at least the class of boys that was wanted. Now that the war had withdrawn so many apprentices, there was not the requisite number to spare to take up studies, and that was one of the chief reasons why the Apprenticeship Committee were

not following up their work. But he quite agreed that the most important thing was to make the foundry attractive to the boys. It was hardly to be expected that a boy getting up at five o'clock in the morning and working all day in the foundry, and getting home at about seven o'clock was likely to rush back to an evening class, and even if he were persuaded to do it he was not in the condition to be a successful student. The first place that needed reform was the foundry, and to do that they must tackle the employers. It was a remarkable fact that, as a rule, no foundryman would put his boy into the foundry, nor would the average moulder or patternmaker. They got their apprentices chiefly from the sons of the labourers, and very often the boy was the cast-off from everybody.

Mr. T. Reid (Technical School) said that in the main he agreed with Mr. Howell's ideas. Mr. Broughall, however, had pointed out the absolutely essential need to be met before they got the type of boy who could be advantageously trained to become a moulder. The first essential was a good, honest education, not the education given in the schools at the present time, which rambled all over everything. The great essential was to encourage the boy ultimately to extend his knowledge when once he had attained to the position of being a good workman and citizen. That grounding of education was the fundamental necessity With regard to the actual trade training, that required to be broken up into proprietory trade training and works training. The idea being that works training was necessary to give him the requisite experience. He hoped Mr. Broughall would give a little further consideration to one aspect of the trade. He agreed with him largely that the main experience was to be got in the works. From his own knowledge of foundry work—and he served some time as a moulder for the sake of getting the practical experience of the foundry, which every designer must have—he was convinced that there was an enormous advantage to be gained in taking lads through a regular training in methods of moulding. They could afford to do in a school what an employer could not afford to do in the works—they could afford to make scrap intentionally. It was quite a good thing to instruct a youth in a certain way, and leave out an essential factor. For instance, they might select a type of pattern which was pretty sure to give bad results in the casting. That was a kind of object lesson, very useful as a sort of negative training, i.e., to make him do the wrong thing to teach him what to avaid. The effect would be to save the employer many a scrap heap which would be produced while a lad was gaining experience. Another difficulty was to get a boy engaged in the foundry to take up other classes. In that school they insisted as far as possible that a boy should not go in for foundry study unless he took up some other correlative course. For example, the boy in the foundry would be quite useless unless he could read engineering drawings. Otherwise, he could not check the work that he had to do. It might possibly happen that work was not properly measured up. The effect of that would be that when the casting came out it did not agree with the dimensions. Obviously, the moulder in embryo, should know something about patterns, while on the other hand the patternmaker should know something of moulding. Obviously, also, the designer, whose duty it was to get out the design for machining, should know something both of patternmaking and moulding, so that he might understand the difficulties that moulders had to contend with in carrying out work. He had been in Birmingham 18 years, and about 12 years ago they started moulding classes. But the difficulty was to get support both from employers and from managers, such as were now present, who had positions of authority in connection with large firms. It was necessary, also, to get essential support from the city authorities if the work was to be carried on. Such classes could not be started unless the authority was willing to spend a reasonable amount of money. It was for the foundrymen themselves to impress that view upon the authorities, so that every boy entering into his trade could have proper training. Facility ought to be given to carry out in the school or the university experiments such as must have occurred to many of those present, but which could not possibly be carried out in the workshop. Many defects could be got over if men controlling large firms had opportunities to carry out in a leisurely manner such experiments as were necessary. He believed that the whole system of technical schools and continuation schools was in the melting pot, and if foundrymen and others would take an interest in the matter and exercise their influence they would enable the country to hold its place among the great industrial nations of the world.

Mr. Howell, replying, said he had no intention of advocating that a boy should go to a technical school to learn his trade, nor did he favour, as Mr. Cook suggested, the putting of old heads on young shoulders; but he still believed that it was necessary to so develop the boy's intelligence that he should take the long view. There was a good deal in what Mr. Shaw said about the state of the foundries. They needed proper places for changing clothes and for washing, so that they could present a respectable appearance when they went into the street. With regard to the unfortunate experience of the formation of some classes, he himself had fared somewhat better. On Mr. Cook's advice he decided to hold a little class at his own home, and for four years he held that class and the attendance was remarkably good. Indeed, when Mr. Cook was the speaker they very rarely got anybody absent. He believed that, on the whole, the technical authorities were willing to help them, especially if they could get hold of the right type of boy.

LANCASHIRE BRANCH PRESIDENTIAL ADDRESS.

At a meeting of this Branch on October 5, Mr. Samuel Roe, of Oldham, delivered his presidential address, the subject being "The Training of Apprentices." He said, in the consideration of any subject valuable information was often obtained by a study of its history, and in the case of iron historical research was of considerable interest, though it yielded little that was practically helpful to the foundrymen of the present day.

The working of iron was of great antiquity and in several countries its discovery was ascribed to forest fires. The most ancient of these traditions was found in the Chinese Book of Historical Documents, in which Fuh-Li was described as having accidentally smelted iron from a brown earth when clearing away a forest somewhere about 3200 B.C. No further mention of iron was found in the annals

of this ancient civilisation until 400 B.C., when Leih-Tze described a method of converting iron into steel by melting and refining. Among the nations of antiquity the Chaldeans, Assyrians, Hebrews, Medes, Persians and Egyptians were acquainted with the use of iron of the beaten variety only, and the same remark was true of the European barbarians prior to their coming in contact with Roman civilisation. The discovery of the art of casting statues in iron was ascribed to one Theodorus of Samos, who (on the authority of Aristotle) lived in the fifth century B.C., and several ancient authors had described such statues, but they gave no information as to the methods followed. Perhaps the most noticeable piece of moulding work done by the ancients was the casting of the pillars, and the molten sea for the House of Solomon, some 900 years B.C., but these were in brass. The pillars were 27 ft. long by 6 ft. dia., the molten sea 15 ft. dia. and 7½ ft. high. One significant passage in the description of this work said:—"Solomon left all the vessels unweighed because they were exceeding many; neither was the weight of the brass found out." One must suppose that the knowledge of mensuration was very small or non-existent, and that the makers of the castings had greatly exceeded the capacity of their measuring and weighing instruments. Another gigantic casting, attributed to Cheres of Lindos, was the Colossus of Rhodes, a hollow bronze statue about 107 ft. high, which was said to have taken 12 years to set up. It was erected about 270 B.C., was overthrown by an earthquake in 222 B.C., and lay in ruins until in the middle of the seventh century A.D., it was broken up by the Saracens and sold as scrap metal to a Jew.

Coming nearer home, no mention was made by early English writers of objects in cast-iron, but the presence in Burwash Church of a cast-iron tomostone proved that the art was known in Essex in the middle of the fourteenth century. It seemed to have been practically confined to the production of domestic utensils until the middle of the seventeenth century when cannon and shot were cast in iron. In those early days the methods were primitive, but the makers were practical men, and obtained the desired results.

As the industry progressed, continued Mr. Roe, it became imperative that the foundryman should know something about the materials used and the natural laws governing them. To-day he must go further and acquire some portion at least of the knowledge required by the moulder, chemist, mathematician and physicist. But while the engineer, builder, plumber and others had no difficulty in finding a curriculum adapted to their special needs, because classes and laboratories catered for their particular trades, the foundryman who was determined to gain all the knowledge necessary for his requirements must search in several curricula, and to the normal youth the task appeared so formidable that only the more courageous and ambitious would attempt it.

Leaving aside for the moment the practical part of the trade, there were three subjects, purely theoretical, which had a powerful bearing on the education of the foundryman. In the first place there was mathematics, in the sub-divisions arithmetic, mensuration, algebra, geometry, trigonometry. What was the irreducible minimum of knowledge which the foundryman must possess? Supposing he came to the workshop at the age of 13, he should then have attained to or passed the 6th standard of the elementary school, and in arithmetic that would mean he had entered the region of vulgar and decimal fractions. But unless he attended continuation classes his knowledge of that stage of arithmetic would rapidly rust and fade away. This has been proved by the author's experience with his own apprentices. Therefore it was advisable that the teaching of this stage of arithmetic in the continuation class should overlap that given in the elementary school. Examples ought to be given freely in the least common multiple, the highest common factor. Vulgar and decimal fractions should be dealt with, and a knowledge how to convert the one into the other was necessary. Mensuration was most useful. The foundryman must be conversant with the rules governing the rectangle and triangle, the circle, the ellipse, the methods adopted in getting the contents of sphere, cone and pyramid. Examples worked in mensuration should be applied to familiar articles, *e.g.*, calculations of areas of melting zones of cupolas, the weight of a ladle, giving the two diameters and depth, the weight of metal required to fill a mould of given dimensions.

This would give the young foundryman confidence that the knowledge he was obtaining would be of value to him. Only a slight knowledge of geometry was necessary. Geometrical drawing and plain geometry should be taken in conjunction with the instruction in mensuration. The various figures dealt with in mensuration should be set out to scale and instruction given in the use of mathematical instruments.

With regard to algebra the foundryman had no need to struggle to dizzy heights or master the calculus and conic sections. The important portion of the subject in his case was that which dealt with symbolical expression and simple equations. Practically all the calculations required from a foundryman were of the nature of, or could be reduced to, the form of a simple equation. But before this knowledge could be obtained some considerable amount of spadework must be done in the shape of the various steps leading up to the equation.

Trigonometry was of no practical value to the foundryman.

Physics was that branch of science which dealt with mechanics, heat, light, sound, magnetism, and electricity. The last four could be dismissed as interesting to the seeker after knowledge, but not essential in the curriculum of the foundryman. Mechanics was a wide subject, with several subdivisions. Putting aside the study of velocity, motion, acceleration, etc., and the purely theoretical part of the subject, the foundryman was most concerned with the appliances designated by the text-books as the simple machines—the lever, the wheel and the pulley. An elementary knowledge of their properties was all that was required. As a concrete example of the lever, take the indirect method of weighting the top part of a mould. Some top boxes were so full of core supports, vent pipes, etc., as to leave very little room for the necessary weights. The method adopted in such cases was to bring into use an outside support for the ends of the bars or beams which were to carry the weights, the other end being accommodated on the small portion available of the top parts. It became then a simple problem of the lever in calculating how much of the weight was borne by the box and how much by the outside support. Of course very few foundrymen applied scientific knowledge in ascertaining the upward pressure exerted by the

molten metal poured into a mould, and the calculation of the necessary weight to resist this pressure. The usual method was to overwhelm the mould with weights, sometimes to the undoing of the mould joint.

A simple knowledge of the wheel and the laws governing the wheel train was necessary. Simple calculations were often required relating to the number of revolutions of a certain wheel with a known number of teeth, transmitted to another at the end of a train of wheels. This was particularly so in foundries where the wheel moulding machine was employed. In most foundries this was left to the draughtsman who placed the use of the machine on a much lower social level. Calculations applied to wheels were also applicable to the pulley.

Hydrostatics was the science which treated of the weight and equilibrium of fluids. From the definition it was clear that a small portion must be included in the foundryman's curriculum, because the molten metal obeyed the laws which governed fluids. The laws which should be known to him are these:—

Fluids press equally in all directions. If a vessel, the bottom which is horizontal and the sides vertical be filled with fluid, the pressure on the bottom will be equal to the weight of the fluid. If a vessel whose base is horizontal be filled with fluid, whatever the form of the upper portion of the vessel may be, the pressure on the base will be equal to the weight of a vertical column of the fluid whose base is the same as that of the vessel, and whose altitude is the depth of the bottom below the horizontal surface of the fluid. The hydrostatic paradox and its meaning should be known to him. It is that by means of a fluid any pressure, however small, might be made to balance any other pressure however great. A knowledge of these laws and their application to molten metal, combined with a knowledge of mathematics, would enable him to make any calculation necessary for him. By the study of heat a knowledge of fusion and solidification was gained. The effect of heat on solids, liquids and gases, the use of the instruments—thermometers, pyrometers, etc.—used in determining various temperatures, the difference between the Fahrenheit scale and the Centigrade scale, and the method of converting one reading to another, all should be known. Along with the study of physics the foundryman should take engineering drawing. Portions of the machines common to the engineer's shop—the lathe, the planer, the drill—and the sources of power (either steam or gas engines) should be copied. There should be instruction in the reading of drawings as they left the draughtsman. Thus the foundryman would become independent of the diagrammatic sketch or working drawing which it was so often necessary to supply.

In the whole range of knowledge required by the foundryman chemistry was the *piece de resistance*, but in this science, as in the others previously mentioned, there was much that he did not need. A curriculum should be arranged which, whilst containing no more than was necessary, would give an adequate idea of the importance of the science. Such a curriculum might be arranged on the following lines:—

States of matter, solid, liquid, gaseous.
Experiments to prove indestructibility of matter.
Experiments showing the difference between physical and chemical changes.
Explanation of terms.
Elements and compounds; atomic theory.
Definitions of atom and molecule.
Definitions of solution, precipitation, crystallisation.

From this the student might pass to the preparation of the two gases, hydrogen and oxygen, and an explanation of their properties. Here it might be expedient to explain chemical notation, symbols, formulæ and chemical equations, along with examples in chemical arithmetic, and then consider the list of elements as given in any text-book on chemistry. How many of these was the foundryman interested in? First, those which he encountered and had to deal with in the foundry. The list might be reduced to: Aluminium, antimony, calcium, carbon, copper, hydrogen, iron, lead, magnesium, manganese, oxygen, phosphorus, silicon, sulphur, tin and zinc. The properties of these elements should be studied, and their reactions on each other shown by experiment. Salts containing these elements should be analysed qualitatively and subsequently quantitatively, not with any idea of making the foundryman capable of acting as his own foundry chemist but to familiarise him with the properties of the elements and their relations with each other.

This was the minimum of the theoretical knowledge which a foundryman should possess who wished to be on top of his job and enjoy his evenings at home or elsewhere without carrying around with him the cares of his foundry. By "foundryman," was meant, he took it, a man in charge of a foundry, or who was appealed to in all its departments. The range of knowledge indicated was not necessary to enable a man to become a good moulder; indeed, one of the best moulders he knew could not even write his name. But if the moulder wished to become a foundryman, in the proper meaning of the word, he should acquire this knowledge. His laboratory would be simply a well-equipped foundry designed for the moulding of all classes of work. In one part there would be a framing shop for heavier so-called jobbing work. Other portions would be utilised for bench moulding and loam moulding. A cupola, which the apprentice could handle—*i.e.*, put in the back, the front, fire, charge, tap out, and bot up would be available. Sand mixing machinery would be in operation, and mixings of sand made. The student would be allowed to familiarise himself with the instruments by which metal was put through physical tests. It was unfortunately a fact that some boys apprenticed to moulding commenced and finished their apprenticeship in a shop where only one kind of moulding was carried on, and when it became necessary to make a change they were up against a hard task. With such a laboratory as he had indicated a knowledge of all classes of foundry work could be gained.

Discussion

Mr. Meadowcroft said that at the present time much, if not most of the teaching given outside the foundry did not seem to have any relation to practical work. It had been mentioned, on a previous occasion, that one could not get boys to come from the school to the foundry because the boys did not realise what the foundry was. They were preparing to become mechanics, draughtsmen, and the

like, and all that they learned was from that standpoint. A simplified system for bringing them into the trade was necessary. As teachers they wanted men with a very intimate knowledge of foundry conditions who could harmonise scientific facts with ordinary working practice. The knowledge which was picked up in reading and study had to be assimilated before it could be "taken into stock," as it were, and applied. A great deal of good would be done by pointing out to apprentices the application of theoretical knowledge to the jobs which they were engaged upon, and he hoped that something on these lines would be done in Manchester. There was a large foundry, he understood, in the building, but it was practically derelict. It was a problem for the Society to tackle, and he believed something would be done immediately after the war. Exactly what would happen he did not know, but the spadework done by the Association would bear fruit. There was no doubt that foundries were going to be altered, and the present methods must be greatly improved if this country was to take its proper place in trade. The men were not going to have as hard work as hitherto. They were getting higher wages; higher wages would mean greater invention, and people being stimulated to save as much as they could.

Mr. Haigh said the historical side of the paper was interesting. Apparently 3,000 or 4,000 years ago men were able to solve successfully problems which even in modern practice would be very difficult. But he was more concerned with the paper as it treated of present-day conditions. Up to ten years ago it was not thought necessary to provide any education for foundry lads; they struggled on and ultimately became moulders if they had a certain amount of ambition. Often they did not. One of the most hopeful signs at the present time was the attention which was being paid to the education of that class, for example in the provision for continuation schools embodied in Mr. Fisher's Education Bill. In one town the idea had been tried. A number of apprentices were sent from the foundry to the evening school, and 50 per cent. at least went through the whole session. A large number were now attending morning and afternoon schools, and he hoped that twelve months from now the Municipal Council would hear a satisfactory report of the results. It was difficult to make a lad of 14 understand what mathematics, physics and mechanics had to do with moulding, but it was there all the same. In the past the moulder had not taken advantage of technical education, and now he was not able to instruct the lads where those things came in, so it was incumbent upon the management to do all they could. The technical schools could teach many things, but they could not produce moulders; that could only be done in the foundry, and unless the teacher's instruction was followed up by training in actual work, the benefit would be lost in great measure. Therefore he would like to see apprentices 14 to 16 years of age placed under the care of experienced moulders who would show them the practical application of the lessons.

Mr. Key said one of the greatest difficulties was to get a satisfactory basis to work upon and formulate a scheme which would carry out the ideas of those gentlemen who had spoken or written on the subject. The first thing to consider was the environment of the foundry. When the lad came in was there sufficient inducement for him to study and make himself highly trained? Was it not likely that he would look for something which would give better scope for his abilities and knowledge? It was necessary to improve on the conditions of the past, and the trade could be organised on lines which would remove some of the trouble formerly experienced. Specialisation could be carried out to a much greater extent. Certain districts might have assigned to them particular classes of work. Besides providing for the supply of good moulders they had to train people competent to fill the higher posts, where an education of a technical nature, coupled with intimate knowledge of workshop conditions was required. The work could not be done by the Government alone. He had in his mind a factory started by the Government where practically everything in the foundry trade was done. Three or four men trained in that place had been through his hands, and they were useless when they were required to turn out a day's work. They had been taught a lot of things but not how to work. The successful manager of the future must have technical education; he must also understand human nature, and unfortunately a number of foremen and managers of the present day did not seem to possess that qualification.

The Chairman (Mr. P. Roe) said what was wanted was a curriculum. It was a great task to pick up the knowledge from text-books and classes intended for other trades, and to spend years in searching for and putting together for oneself what might be compressed into one small volume.

CADMIUM.—Cadmium lowers the melting point of alloys, and is therefore employed in making fusible alloys and soft solders, such as those used in the fusible plugs of automatic sprinklers and the fusible safety plugs for boilers and electric fuses. Since tin has become scarce, cadmium has been increasingly used as a substitute for it in solders, such as the "half-and-half" lead-tin solder. Though cadmium is worth half as much again as tin it can be profitably substituted for tin in some solders, for less cadmium and more lead is used; moreover, the tin available is required for uses for which there is no substitute. The author of a recently issued bulletin of the U.S. Geological Survey considers it desirable that some research laboratory should undertake an intensive study of cadmium, particularly of its alloys, to determine fully the availability of cadmium as a substitute for tin and to discover new uses for it. Before it was produced in the United States in large quantities the bulk came from the zinc-producing regions of Silesia, where it is recovered as a by-product in the distillation of zinc. Another source is the residue left in making zinc chloride from low-grade zinc ores and from zinc ashes and drosses. Still other sources which may become important are the anode muds resulting from the electrolytic refining of spelter and the muds that are precipitated in purifying the electrolyte preparatory to depositing zinc in the reduction of zinc ores by leaching and electrolytic deposition. The fumes driven off in making brass are richer in cadmium than the spelter used, for the more volatile cadmium is driven off in greater proportion than the zinc and is thus concentrated in the fumes. Zinc-oxide flue dusts recovered from brass works show 2 to 3 per cent. of cadmium. The output of metallic cadmium in the United States in 1917 was 207,408 lbs., besides 50,169 lbs. of sulphide, as against 135,212 lbs. and 22,176 lbs. of sulphide in 1916. The output of Germany in 1913 was 81,993 lbs. of metallic cadmium. No figures of a later date are available.

Welding.*

By Engr.-Lieut.-Commdr. L. Jackson, R.N.

Welding is one of the oldest operations in the art of the working of metals, and consists of the intimate and complete joining up of two surfaces of metal, without fusion, by pressure or by hammering. The welding range of a metal exists only within a limited range of temperature and in iron and steel is within 100 deg. of the melting point.

In the ideal weld the two surfaces to be united are brought together at the welding heat, and then either hammered or pressed, and after the operation the point of juncture should be as strong, relative to its section, as any other portion. Welding is now an important and well recognised operation, and is used in the construction and repair of innumerable articles.

In 1877, Holley advanced the theory that irons weld in proportion to their mobility, or power to flow, and inversely as oxidation of their welding surfaces occurs; he thought that the more plastic or the nearer to the melting point the irons were, the more readily they would weld, but with every increase of heat was a corresponding readiness to oxidise, especially on the part of carbon and iron. Oxide interposes a mechanical difficulty to perfect welding, and limits to very few metals the facility of welding.

Were it not for the recent remarkable advance due to the electric, oxy-hydrogen and acetylene processes of melting, welding would be confined to iron, platinum, nickel and gold; other metals would be joined by soldering and brazing, and even then the metal worker would have great difficulty with aluminium and many alloys.

Electric welding processes have been used commercially since about 1880, when Thompson brought out his low-pressure resistance machine, in which the alternating current is used with a high amperage and low-voltage, and is used very extensively for repetition work such as welding the links of chain, etc., and though the several processes in which electric current is used in welding are unlike as regards apparatus and application, the basic idea of each process is to produce the welding heat by means of resistance to an electric current. Amongst the principal processes used in electric arc welding is the Bernardos system, and in a paper read by Mr. R. S. Kennedy, before the Institute of Marine Engineers on March 12 of this year, he informs us that this process was the first to be employed in a commercial sense and consists of the use of a carbon electrode, an arc being drawn between the carbon and the metal to be welded, a portion of which is brought to welding heat, the added metal being heated in the flame of the arc. In the early Bernardos process the work was made the negative pole, and the carbon the positive, but latterly the poles were reversed, thus doing away with the danger of carbonisation of the metal, caused by the natural flow of carbon particles from the positive to the negative.

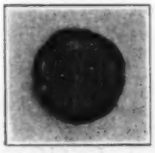


Fig. 1.

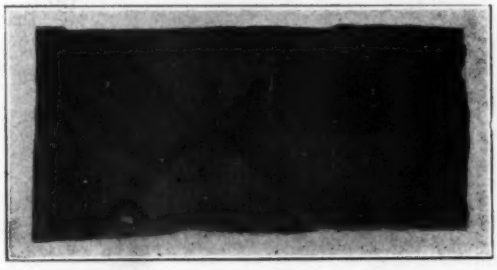


Fig. 2.

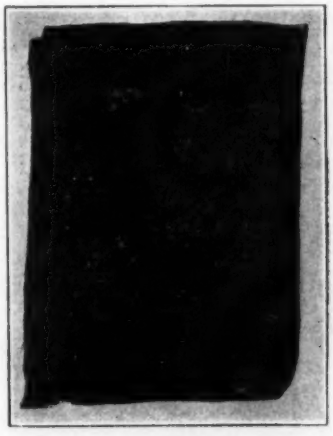


Fig. 3.

Slavinoff substituted a metal electrode for the carbon electrode, and Mr. Kennedy claims that his firm, the British Arc Welding Company, were the first to employ the metallic electrode in this country on a commercial scale. It is well known that Nature has provided that the positive pole of the electric arc should be much hotter than the negative pole, and consequently it is arranged in electric arc welding that the positive pole shall be on the bigger mass, which, generally speaking, is the job, and the negative pole being on the smaller mass of metal which in modern electric arc welding is the metallic pencil of the adding material. By those means favourable conditions are provided for the first essential of a good weld,

* Read before the Lancashire Branch of the British Foundrymen's Association, November 2, 1918

namely, that the pieces to be united should be brought to a welding heat at the same time.

The Quasi Arc Company has introduced a process of fusion welding which it claims is superior to the oxy-acetylene and carbon arc processes, inas much as no pre-heating is required, however large the work may be. In this process the highly localised heating agency of the electric arc is employed to bring about autogenous union, the fusion starting immediately the arc is struck, but under such conditions that it is claimed that throughout the whole operation the fused and adjacent metal is entirely protected from all oxidising influences, and all danger of carbonisation is eliminated owing to the use of steel in place of the carbon electrode. This result is apparently obtained by the use of their patent electrode, which consists of a mild steel core.

Fig. 1 shows a section of the electrode, by the side of which is laid a thin aluminium wire, and wrapped round the core and embracing this wire is a mineral fibre; with the help of additional materials this fibre is given a suitable chemical composition, which makes it a perfect flux for the steel when the electrode is fused by means of the electric current.

The importance of forming a joint which shall contain no trace of oxidisation or carbonisation is so great as to deserve particular emphasis; not only does the presence of oxide greatly reduce the strength of the weld, but it renders the joint peculiarly liable to corrosion. The addition of carbon may render iron and steel hard and unworkable, and cause cracks to be formed during cooling.

Repaired Casting by Quasi Arc Process.—A steel casting during cooling developed a defect known as a pull, which extended right through the wall, caused by the contraction of the metal. The casting was a steam regulating valve body, and designed to work at a steam pressure of 250 lbs. per sq. in., which means a temperature of about 405 deg. F. It was decided to repair the defect by means of electric welding, the Quasi arc process being employed. No pre-heating was resorted to, the fissure was simply opened out somewhat to allow of the more efficient employment of the electrode. The arc was struck, and the metal began to deposit in the void protected from oxidising by the slag formed by the fusion of the electrode coating. The operator gave the electrode a lateral movement, and kept the point well down to the work, just in contact with the molten slag, and at such an angle as to keep the molten metal and slag in front of the electrode. The slag of course deposited on the top of the metal and very rapidly cooled; thus the first layer was deposited. The slag was then chipped off by means of a small chipping hammer, the arc again struck, and the second layer deposited, and the process repeated until the void was filled, the other side of the weld being slightly fused away and filled similarly.

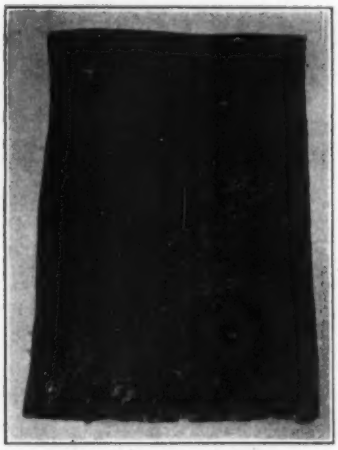


Fig. 4.

Fig. 5.

The valve body was then annealed and afterwards secured in such a manner as to be subjected to the thrust and twice the internal pressure it would break at. A thrust of 70 tons was applied by the ram of the hydraulic press, and 500 lbs./sq. in. internal pressure by means of the hydraulic service, and these two forces were maintained for four hours, the casting being well hammered before releasing the pressures. The pressure and load were then put on and released intermittently several times. No signs of leakage appeared, and the valve box was considered fit for its purpose.

It was subsequently considered advisable to have some experimental test pieces done by ordinary electric welders, *i.e.*, such as are usually employed in a foundry; they were prepared and welded in the manner just described. Fig. 2 shows a photograph of a specimen weld. It will be observed

that the cast-steel bar has been cut in two and the ends well bevelled off, one side being welded and then the other. Test pieces were prepared from them, and the result obtained as follows:—

Test No.	Max. stress.	Elong %.	R. of A. %.	Efficiency.
1 ...	26.5	13.0	30.5	88.3
2 ...	19.4	4.5	24.5	64.7
3 ...	20.4	7.5	24.5	68.0
4 ...	20.5	12.5	32.0	68.3
5 ...	18.6	4.5	15.0	62.0
6 ...	21.0	6.5	16.6	70.0
Averages	21.1	8.1	23.8	70.2

Silica	36.65
Alumina	5.12
Ferric oxide	7.77
Ferrous oxide	40.46
Manganese oxide	4.46
Lime	0.70
Magnesia	1.91
Sulphur	0.03
Phosphorus, less than	0.01
Carbon (by combustion)	0.08
Total loss on ignition corrected for oxidation of ferrous oxide to ferric oxide ..	0.79
Alkalies by difference	2.02

Fig. 8 is the structure of steel near a weld. It will be seen here that the steel has been obviously over-heated, and to obtain the best physical condition should be annealed before being put into use.

Fig. 9 is a micrograph unetched taken from sample shown in Fig. 5. This (Fig. 9) shows that in addition to the cavities seen in the photograph there is also trapped slag, both this and the cavities naturally reducing the efficiency of the welding operation.

When the United States entered the war on the side of Great Britain and her Allies, and took over the interned German and Austrian vessels located in the port of New York, the authorities set themselves at once to the task of fitting the vessels for sea. It had previously been discovered and announced that the machinery of the vessels had been bady damaged by the crews. The rapid repair of the vessels was of the greatest import-

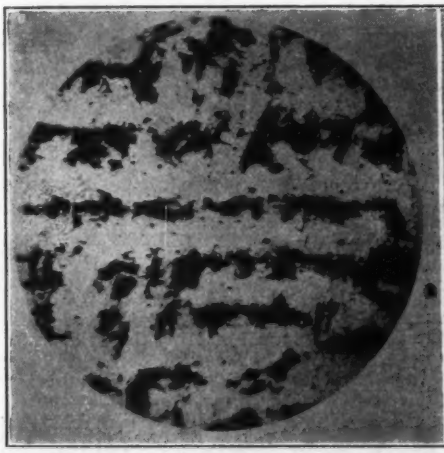


Fig. 6.

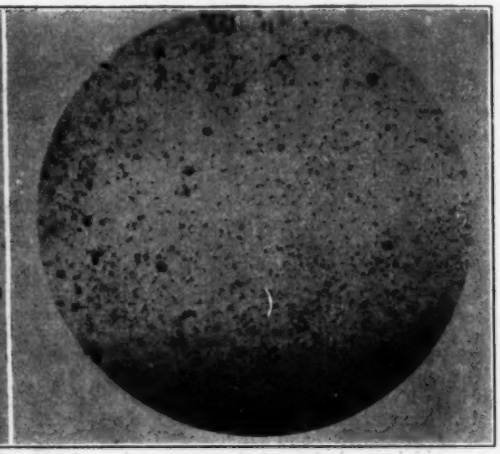


Fig. 7.

	Welding rod.	Welded metal.
Carbon	.08	.11
Manganese	.47	.17
Silicon	.015	.18
Phosphorus	.05	.067
Sulphur	.067	033
Chromium	Nil	Nil
Nickel	.11	.20

Fig. 3 is a photograph of the fracture through the centre of the weld, and Fig. 4 a photograph of the fracture away from the centre of the weld. Fig. 5 is a section of a defective weld; etched to bring up difference between steel and weld. This contains, as will be seen, a number of cavities due to lack of experience on the part of the operator.

Fig. 6 is the structure of steel welded. This shows the normal structure of steel, being ferrite and pearlite, about 0.3 per cent. carbon. Fig. 7 is the structure of the weld, and indicates the appearance of the filling-in material. As will be seen, there is very little carbon present. This lack of any appreciable percentage of carbon is advantageous in that low-carbon steels give better results as cast than those with higher percentages, and by this means better results are obtained in cases where welding is not followed by annealing. In this connection the effect on the steel next the weld is of interest.

ance, and Commander E. P. Jessop, U.S. Navy, in a paper entitled "Repairing German Vandalism by Electric Welding," contributed to the "Journal of the American Society of Naval Engineers," reveals some interesting details, with photographs of the damage done and how the repairs have been effected. The principle of electric welding was applied to 15 ships in the Port of New York, and in no case did the repairs to the propelling machinery of the vessels delay them beyond the time necessary to equip them as transports. In other words, largely by the use of electric welding, all the vessels were got out as quickly as would have been the case had no damage to the main machinery been done by the Germans.

In order to successfully weld with the electric arc in connection with cast iron, it must be noted that cast iron is not welded to cast iron direct. Special alloy steel wire is used to supply the welding material. In welding two cast-iron edges together, a layer of steel is welded to each, and then these two layers are welded to each other. It is difficult to weld two cast-iron parts together, but comparatively easy to weld a steel piece to a cast-iron piece. In electric welding the work can be done without pre-heating the parts, and without removing the parts from the ship, provided

the electric arc can be properly directed along the fracture.

The *Prinzess Irene* was sent to the Navy Yard, Brooklyn, for overhauling, and complete photographic records of work done on the main engines of this vessel were kept. No trouble ever developed with regard to the welds after they were pronounced finished.

Fig. 10 shows a break after being prepared for

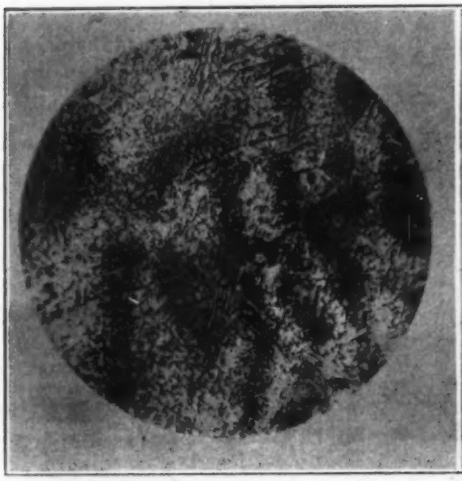


FIG. 8.

FIG. 9.

welding, and it will be noted that the cast-iron side of the H.P. cylinder is studded. This is not done as a necessary part of this repair, as all tests of welds made by the welding apparatus have shown practically the same tensile strength as the material which was welded. This laying over of metal on the cast-iron side of the weld was merely done as a precaution, and to increase the strength of the weld beyond that of the rest of the cylin-

FIG. 10.

der. Studding up the cast-iron side of the break has also been the subject of much criticism, numerous engineers having jumped to the conclusion that the repair was not made by welding the cast iron nearly so much as it was made by welding around the steel studs which had been embedded in the cast iron. This, however, is not a criticism that is vital, because it was only necessary that the cylinder welded be rendered as strong as before the break, and this undoubtedly has been accomplished.

The welding done on the *Prinzess Irene* was the first straight electric welding in any of the 15 vessels repaired. In all previous cases the scepticism of the engineers who had immediate control of deciding upon the form of patches which should be used, caused them to have patches cast, overlapping the cylinder walls and then bolted to the walls, so that part of the pressure was taken by the bolts, and not all of it by the weld, as in the case of the *Prinzess Irene*.

In some of the other ships the original intention

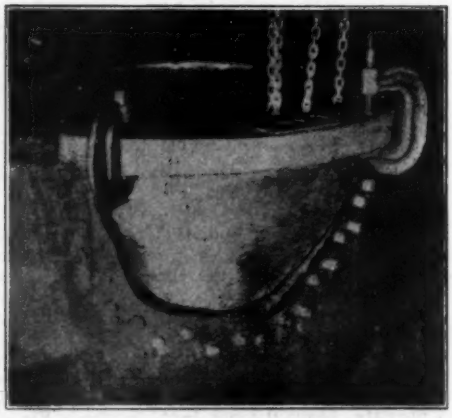


FIG. 11.

was to repair the cylinders by mechanical patches. These patches were made of composition, and in most cases were in the form of inserts between cast-iron sides of the breaks. However, this method was discarded, and cast-steel patches substituted. The amount of fitting necessary to make a mechanical patch steam-tight is shown by the fact that ten weeks after the repairs to one ship

had started the machinists were still at work on these patches scraping them to a fit. The difference between this method and that of welding steel patches is shown by the fact that many of the patches on the *Prinzess Irene* were fitted in 48 hours ready for welding. In other words, they were not fitted at all, but merely bevelled off to receive the welding material.

Fig. 11 shows the insert in place ready to weld, with the metal bevelled off. Fig. 12 is the finished weld. Fig. 13 shows the I.P. valve chest of *Prinzess Irene* ready for the insert. It can readily be seen what an extensive fracture this was, and the amount of welding required to repair can be realised. Fig. 14 shows the insert for I.P. valve chest in place ready for welding, and Fig. 15 the

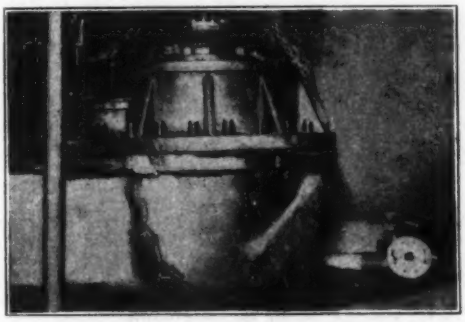


FIG. 12.

finished weld. The amount of welding is here evident.

In summing up, Commander E. P. Jessop invites particular attention to the following items with regard to electric welding and its proper application. In welding cast iron it is particularly essential that the welding metal be laid on the cast-iron surfaces with the greatest care, since it is the juncture between the cast iron and the weld-

FIG. 14.

ing metal which is liable to be inferior. To accomplish this the welding metal should be laid over the cast-iron surfaces wherever possible before the patches are put in place. This method gives the welder more room to work and permits him to keep a steadier arc, and thus reduce the probability of too much or too little heat spoiling that part of the weld. This metal as it is laid on the cast-iron surface must then be peened by a caulking tool in order to develop any hard spot or spots where contact is not good. After this part of the operation is completed, the patches should be put in place and the completion of the weld then is merely welding of steel to steel, which is a very simple process. It is thought to be a remarkable fact that in all the work which has been undertaken by the electric welders in these ships there has not been a failure, this in face of the fact that the work has been very much more ex-

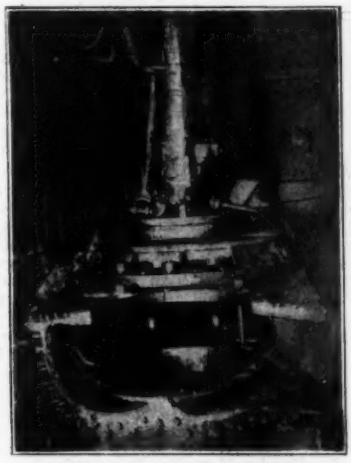


FIG. 13.

tensive than any ever before attempted. It cannot be too strongly insisted that in every case in which the method has been used the repaired job has been fully as strong as it was before the damage was committed, and in most cases stronger in the particular part affected.

In conclusion, the writer would like to say that in some of the German interned vessels a number of castings were repaired by the oxy-

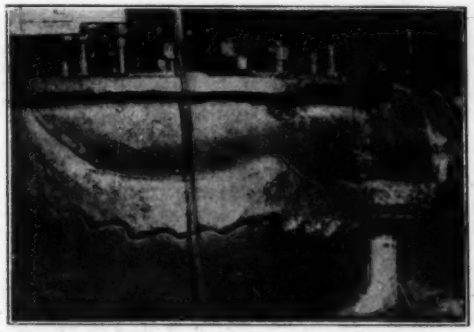


FIG. 15.

acetylene process, with excellent results. Acetylene welding is fundamentally different in application, and while in arc welding every effort is made to keep the vicinity of the weld cool, in acetylene welding pre-heating is employed, and the actual filling of the V slot is done in lengths of about six inches. The sides of the slot are actually fused with the torch, and small pieces of welding rod and flux added to the puddled metal.

Reconstruction Problems.

According to a Parliamentary Paper just issued, the Minister of Reconstruction has appointed the following bodies, other than committees required to report on specific terms of reference, to advise him on different aspects of the various problems which come before him :—

Advisory Council.

The Advisory Council consists of a panel of both men and women of mature experience, from whom the Minister of Reconstruction can obtain practical and competent advice on any questions of special difficulty or complexity that may arise in connection with his work. The Council is divided into five sections, each under the direction of a chairman and vice-chairman selected from the members of the Council. The chairmen and vice chairmen of the different sections of the Advisory Council will meet, as a rule, once a week, to advise the Ministry informally on any points of difficulty that may arise in the daily work of the Department, and to suggest convenient methods of machinery for approaching questions of great complexity and importance. An informal committee of women members of the Council, under the presidency of Lady Emmott, will also meet regularly to give the Ministry similar advice in connection with questions affecting the position of women. The Council includes the following sections, additional members to which will be appointed from time to time, as may be necessary in connection with further developments of the work of the Council and of the Ministry as a whole.

Section I. (Finance, Transport and Common Services.)—Sir Charles Metcalfe, Bart. (who has acted as Chairman in the absence of Sir H. Babington-Smith, K.C.B.), Sir Clarendon Hyde (Vice-Chairman), the Hon. Herbert Gibbs (Financial Chairman), Mr. E. Hussey (Financial Vice-Chairman), Sir Alfred Booth, Bart., the Hon. Robert Brand, C.M.G., Sir E. Tootal Broadhurst, Messrs. Vernon Hartshorn, O.B.E., W. L. Hichens, H. J. Mackinder, M.P., Sir Adam Nimmo, K.B.E., Major the Hon. George Peel, M.P., Sir Alexander Roger, Mr. Ernest E. Spicer, the Right Hon. J. H. Thomas, M.P., Sir W. Rowan Thomson, K.B.E., and Mr. Arthur Whitworth.

Section II. (Production and Commercial Organisation.)—Sir Henry Birchenough, K.C.M.G. (Chairman), Mr. E. Bevin (Vice-Chairman), Mr. J. P. Boland, M.P., Sir E. Tootal Broadhurst, Mr. H. S. Clough, Sir Charles Fielding, K.B.E., Messrs. W. T. Green, J. W. Hope, C.B.E., W. H. Hutchinson, Sir Clarendon Hyde, Messrs. H. J. Mackinder, M.P., J. J. Mallon, Sir Alexander Roger, and Mr. W. H. Watkins.

Section III. (Labour and Industrial Organisation.)—The Right Hon. J. H. Thomas, M.P. (Chairman), Mr. W. L. Hichens (Vice-Chairman), Mrs. E. Barton, Mr. E. Bevin, Sir H. Birchenough, K.C.M.G., Mrs. Butler, Messrs. H. S. Clough, J. F. Duncan., Major-General Sir P. Girouard, K.C.M.G., the Right Hon. Lord Gorell, Messrs. Vernon Hartshorn, O.B.E., J. W. Hope, C.B.E., W. H. Hutchinson, C. A. McCurdy, M.P., J. J. Mallon, Sir Thomas Munro, Sir Adam Nimmo, K.B.E., Mr. Edwin Orde, Sir H. B. Rowell, K.B.E., Mr. R. H. Tawney, Miss G. Tuckwell, and Mr. W. H. Watkins.

Disposal of Surplus Government Property.

The Advisory Council on the Disposal of Surplus Government Property has been appointed "to consider and advise, under the direction of the Minister of Reconstruction, as to the manner in which all stores, land, and other property (except shipping and Government factories), under the control of Government Departments, being property acquired for the purposes of the present war, and no longer required for the purposes of the Departments under the control of which it is, shall be dealt with, whether by the transfer thereof to some other Department, or by the sale or disposal thereof to other persons." It consists of a certain number of members (all named) together with representatives of the Departments concerned.

Engineering Trades (New Industries).

The Engineering Trades (New Industries) Committee was appointed "to compile a list of the articles suitable for manufacture by those with engineering trade experience or plant, which were either not made in the United Kingdom before the war but were imported, or were made in the United Kingdom in small or insufficient quantities and for which there is likely to be a considerable demand after the war, classified as to whether they are capable of being made by (1) women; (2) men and women; (3) skilled men; and setting out the industries to which such new manufactures would most suitably be attached; and to make recommendations :—(*a*) On the establishment and development of such industries by the transfer of labour, machines and otherwise; (*b*) as to how such a transfer could be made, and what organisation would be requisite for the purpose, with due regard to securing the co-operation of labour. The members of the main Committee, together with the sub-committees which have been appointed to deal with particular industries, are as follows :—

The Hon. H. D. McLaren, M.P., C.B.E. (Chairman), Mr. Charles Bennion, Sir George Bullough, Bart., Mr. F. H. Crittall, Mr. R. Dumas, Sir John Griffith, M.Inst.C.E., Messrs. W. B. Lang, Charles A. Lister, C.B.E., P. J. Pybus, C.B.E., G. H. Sankey, Sir Percy Stothert, K.B.E., Messrs. John Taylor, Wm. Taylor, William Thom, Sir W. Rowan Thomson, K.B.E., and Mr. H. C. B. Underdown.

Among the Branch Committees are the following :—

Machine Tools.—Mr. W. B. Lang (Chairman); Mr. J. W. S. Asquith, of William Asquith & Company, Limited; Mr. J. W. Darling, of Darling & Sellers, Limited; Mr. A. Drummond, of Drummond Brothers, Limited; Mr. E. M. Griffiths, of Burton Griffiths & Company, Limited; Mr. H. A. Liebert, of John Holroyd & Company, Limited; Mr. S. H. March, of Churchill Machine Tool Company, Limited; and Mr. H. G. Williams, of Machine Tool and Engineering Association.

Holloware, Sheet Metal, and Pressed Work.—Mr. G. H. Sankey (Chairman); Mr. W. B. Fletcher, of Birmingham Chamber of Commerce; Mr. W. Hall-Jones, of Wolverhampton Chamber of Commerce; and Lieutenant H. Soper.

Miscellaneous Machinery.—Mr. W. Thom (Chairman); Mr. Charles Ray, of Mirrless, Bickerton, & Day, Limited; Mr. H. M. Bickerton, of the National Gas Engine Company; and Mr. E. D. Simon, of Henry Simon, Limited.

Labour Panel.—In connection with this Committee a Labour Advisory Panel has been appointed to advise on all matters arising out of the work of the Committee which affect labour interests. The Panel is composed as follows :—Sir Claud Schuster (Chairman); Messrs. Robert H. Coates, Alexander German, A. Herd, W. H. Hutchinson, W. T. Kelly, Miss Mary Macarthur, Messrs. T. E. Smith, A. B. Swales, Miss Gertrude Tuckwell, and Mr. George Wilkinson.

Raw Materials.

In connection with the supply of raw materials after the war the Minister of Reconstruction is being advised by committees to whom, for their general guidance, the following terms of reference have been given :—

(1) To consider and report upon the nature and amount of the supplies of materials and foodstuffs which, in their opinion, will be required by the United Kingdom during the period which will elapse between the termination of the war and the restoration of a normal condition of trade, and the steps which should be taken to procure these supplies, having regard to :—

(*a*) The probable requirements of India, the Dominions, and Crown Colonies for such supplies at the close of hostilities. (*b*) The probable requirements of belligerents and neutrals for such supplies at the close of hostilities. (*c*) The sources from which, and the conditions under which, such supplies can be obtained and transported, and, in particular, the extent to which they might be obtained from the United Kingdom or within the Empire, or from Allied or neutral countries.

(2) To consider also whether any measure of control will require to be exercised, and the extent and character of such control.

The individual committees include among others those for aluminium, copper, lead, nickel, spelter, tin, and ferro-alloys.

Dr. Addison's Statement.

In the House of Commons, on November 12, on consideration of the Vote of Credit for £700,000,000, Dr Addison took the opportunity of making a statment on the question of demobilisation of the Army and the re-establishment of industry on a peace basis. The following are some of the chief points of the speech :—

We must aim at the restoration of our trade and industry as rapidly as possible. If we are to pay for the war we must aim at better methods of production, better conditions of life, and making a better use of all our resources.

He proceeded to say that he had asked the Ministry of Munitions some months ago to prepare him a report on the state of employment in the metal and chemical trades, and it appeared that 70 per cent. of the men and 40 per cent. of the women were still engaged on work of a kind for which there would be a civilian demand after the war. That made the problem much easier. In round figures, there would be about a million people who would require to change their occupation with the cessation of war manufactures. To turn over a factory from war work to peace work was not a matter of days. It might be a matter of a year or 15 months. They would not solve the problem of the employment of displaced munition workers by expecting to employ them in the same factory. In the main, they would not be absorbed there. What they had to look to was to restore the basic industries of the country which had been shut down, and which were capable of absorbing the great proportion of this labour. The first thing they did when the armistice was practically certain was to arrange with the War Office for the withdrawal of what might be called the "demobilisers" from the Army into the service at home. These were the people who were to assist in the process of demobilisation, to start the exchanges, and the rest of it. Incidentally, he would point out that that part of the scheme involved the issue of a free railway pass to any person who had changed his or her address for the purpose of taking up work on munitions or on Navy or Army contracts, and who desired to take up work elsewhere. . . . Therefore the Government had decided to make provision for such unemployment as might occur during the coming months. The scheme of out-of-work donation for ex-service men and civilian workers was as follows :—Civil workers.—The scheme would be in operation for six months from a date to be appointed, during which the maximum period for which donation might be paid to any individual would be 13 weeks. Soldiers, etc.—The soldier would be entitled to out-of-work donation during the twelve months following his demobilisation for a maximum period not exceeding 26 weeks. The total period for which the scheme, so far as civil workers is concerned, would apply is six months from a given date. In the case of soldiers, the donation would begin to run from the day he personally was demobilised, whenever that might be. Rates of Benefit (ex-service men and civil workers).—Adults.—24s. per week for men; 20s. per week for women; 6s. for the first dependent child (under 15); 3s. for each succeeding dependent child. Juveniles.—Over 15 and under 18 years of age, 12s. per week for boys and 10s. per week for girls. . . . The Government has adopted as its fundamental principle that demobilisation, subject to military needs, must be governed by industrial requirements and broad social considerations. In the next place, it must be remembered that some of the industries of the country have been deprived of the services of men whose return will be essential before employment can be provided for a large number of returned soldiers. It would be folly to bring back into civil life a large body of workers unless the pivotal men were already in their places and the earlier links in the chain of production complete. Full inquiries have been made to ascertain who are the individuals upon whose speedy release the resumption of normal production depends. These pivotal men will be brought back at the earliest possible moment.

It was proposed that State assistance should be given in respect of apprentices whose apprenticeship had been interrupted by war service. No grant was to be payable under the scheme in respect of an apprentice unless he had reached the age at which he would normally have completed his apprenticeship, provided that in no case should such age exceed 23 years in Scotland and 21 years elsewhere; and it would not be payable in respect of an apprentice who was in the last year of his apprenticeship when called up for service. No scheme of training would be approved unless the unexpired period of apprenticeship was reduced by at least one-third. The employer would pay in wages to the apprentice not less than seven-twelfths during the first 12 months, and not less than two-thirds during the second 12 months (if any) of the total of the current standard rate, plus war bonus. The sum payable by the State would be the difference between the weekly wage payable by the employer and three-fourths during the first 12 months, and five-sixths during the second 12 months (if any) of the total of the current standard rate, plus war bonus. In no case would the grant be payable for a period exceeding two years.

The disposal of war stores was a problem which had engaged anxious thought. The Government had accepted in principle a recommendation that a Ministry of Supply should act as the central authority. It would take the place substantially of the Ministry of Munitions. With regard to the rapid restoration of trade, he said he had asked the advice of different groups of gentlemen who had worked hard in giving help. They had to say, first, what were likely to be the requirements of the country after the war. He was glad to say that the position was better than he would have expected.

"The country will desire to know at the present juncture what stocks of raw material are available for peace production, and what preparation has been made to supplement these stocks by importation during the difficult year that lies before us. I will deal first with metals, especially those which are most vital to our industrial welfare—namely, iron ore, pig-iron, and steel. There has been a great increase in our capacity for the utilisation of home ore, and arrangements are being made by the Shipping Controller which will render it possible to import as large a quantity of foreign ore as was imported prior to the war. It is proposed to release iron and steel forthwith. The difficulties which may arise owing to the fact that through the exigencies of war the price of steel now stands at an artificial level have not been overlooked, and it is intended to continue Orders fixing for a period a maximum price for steel, though this may involve continuing some measure of Government assistance for that period."

"With regard to other metals, I am glad to be able to assure the House that there is a sufficient supply available to render it possible to release some from control now, and nearly all the rest within six months."

Parliamentary Notes.

Metal Trade Corporation.

Last month, MR. ROBERTSON asked the President of the Board of Trade whether, and at what date, a company had been formed with a capital of £6,000,000 to do business in metals; whether four of the directors were former members of the Committee on Non-Ferrous Metals; whether several of them were employed in the Ministry of Munitions; and whether the Government had promised the company financial or other assistance.

MR. WARDLE replied that application had been made for the registration of the company referred to. Three of the proposed directors were members of the Departmental Committee on the position of the non-ferrous metal trades after the war. He believed that one was at present engaged in the Ministry of Munitions. No financial assistance had been promised or would be given to the company by the Government, and there was no intention to accord to the company any preferential treatment as compared with other British controlled companies having similar objects.

Wages (Temporary Regulation) Bill.

In the House of Commons, on Nov. 18, Mr. G. H. ROBERTS (Minister of Labour) moved the second reading of the Wages (Temporary Regulation) Bill. He said the main purpose of the measure was to secure that for a limited period of six months, during which industries were changing from war to peace production, the present level of wages should be maintained. The principle of the Bill had been agreed to by the chief employers' associations and trade unions concerned.

MR. TYSON WILSON, on behalf of the Labour party, welcomed the Bill, and it was read a second time.

On November 19 the House went into Committee on the Bill.

MR. G. H. ROBERTS (Minister of Labour) moved an amendment limiting the expenditure under the Bill to £30,000. He said that if it was discovered that this sum would not cover the expenditure it would be necessary for the Ministry to come to Parliament for a supplementary estimate.

The amendment was agreed to.

The Committee stage was concluded, and the Bill was reported to the House, and read a third time.

Restrictions on New Capital Issues.

MR. BONAR LAW, in reply to Sir H. Dalziel, on Nov. 18, said it was not possible at present to relax the restrictions on the issue of new capital for manufacturing firms. The whole question was receiving immediate consideration, but he thought it would be found essential to continue for some time the system of giving priority in the use of available capital, as in other things, for purposes of immediate national importance.

Munitions Act Amendment.

MR. KELLAWAY introduced a Bill in the House of Commons, on Nov. 18, to amend the Ministry of Munitions Act, which, he said, had been rendered necessary by the conditions arising out of the termination of the war.

The Bill was read a first time.

MR. KELLAWAY, moving the second reading of the Bill on Nov. 19, said its object was to enable the Ministry to use the powers given for the production of munitions for the reverse process of getting industry back as rapidly and effectively as possible to peace production. The Bill did not prolong the life of the Ministry, nor did it extend the duration of any existing Order. When the original Act was brought in no one anticipated the condition of things facing the country after three and a half years of the existence of the Ministry now that the immediate need for war production had ceased. Certainly no one anticipated the extent to which it would be necessary for the Ministry to direct existing industries into strange channels, and to foster and create new industries. During these three and a half years it had been necessary to bring about an industrial revolution in this country without parallel in the history of the world.

MR. HERBERT SAMUEL said the country as a whole were looking forward to recovering at the earliest possible moment their much-prized liberties, but he thought Mr. Kellaway had shown that some measure of control was essential during the transition period.

The Bill passed through Committee without amendment, and was read a third time.

The operative clause of the Bill runs :—

The purposes of the Ministry of Munitions shall include the supervision and regulation of the diversion to the production of articles required in times of peace, of industries established or utilised during the present war for the purpose of the production of war material, and all powers which may be exercised by the Minister of Munitions with a view to facilitating the supply of war material, or otherwise for promoting the prosecution of the present war, may be exercised by him with a view to securing that such diversion as aforesaid shall be carried into effect in such a manner as may be most conducive to the national interests, and all orders, requirements, directions, regulations, rules and notices made or given by the Minister, and in force at the passing of this Act, shall, until they expire or are altered or revoked, continue in force as if this Act had been in force at the time when they were made or given.

Committee on Production.

Replying to MR. E. STRAUSS, last month, Mr. Churchill said that the Committee on Production was an arbitration tribunal under the Munitions of War Acts, appointed to hear and determine differences between employers and employed engaged on munitions work, but the Committee had also acted as an arbitration tribunal on differences connected with work other than munitions work in cases where the parties had agreed to submit their differences to the Committee.

Iron and Steel Stocks.

Relaxation of Manufacturing Restrictions.

The Minister of Munitions gives notice that orders and instructions are in course of preparation, and will be published shortly, under which the restrictions which have hitherto existed prohibiting manufacturers from undertaking certain classes of orders, and from using certain materials otherwise than for specified purposes, will be relaxed as far as possible. In the meantime, manufacturers are at liberty, subject to the existing Priority of Work Order, forthwith to use in manufacture, whether for stock or otherwise, any iron, steel, or non-ferrous metals, which they have already acquired by purchase and have in stock; and, subject to any existing restrictions as to price, to accept any orders for manufacture out of such iron, steel, or non-ferrous metals.

In the case of stocks of materials which are held by contractors, but are the property of the Government, application should be made immediately to the appropriate Department of the Ministry of Munitions, who will be prepared to negotiate the terms on which they can be released. In this connection, attention is directed to the fact that release of the materials in question will only be granted to a sufficient extent to satisfy reasonable immediate manufacturing requirements.

Attention is further directed to the fact that, in the event of excessive stocks of materials being collected, it may be necessary to exercise powers of requisitioning such stocks in order to divert them into the most useful channels, having regard to the national interests.

Deaths.

Mr. W. Veitch, engineer and metal merchant, of Ffynone Terrace, Swansea, has died suddenly.

The death is reported of Mr. J. R. Gregg, of the Ferrybridge Foundry Company, Limited, at the age of 27 years.

Mr H. E. Philpot, of Messrs. Philpot & Son, engineers, Canterbury and Ramsgate, has died at the age of thirty-four.

The death is reported at the age of 74 years of Mr. C. Sillavan, of Leigh & Sillavan, Limited, iron merchants, Manchester.

The death took place recently at Philadelphia, U.S.A., of Mr. M. E. Curwen, the European manager of the J. G. Brill Company.

The death took place recently of Mr. T. M. Lambert, of Thomas Lambert & Sons, Napier Forge and Hammer Works, Sheffield, at the age of 37 years.

German papers, just to hand, report the death of Otto Thiel, one of the joint inventors of the Bertrand-Thiel process of steel making in Germany.

Lieut. A W. Ogilvie, a director of Singer & Son, Limited, art metal workers and founders, Frome, has died in a London hospital from pneumonia.

The death is reported of Mr. E. A. Newton, proprietor of the London Ironworks, Halesowen Street, Oldbury. The deceased was 34 years of age.

Lieut. H. S. Mowll, R.N.V.R., whose death is announced, was, previous to the war, in charge of the Scotch branch of Crossley & Company, Limited.

The death occurred at Mansfield recently of Mr. E. G. Halsworth, a director of the Meadow Foundry Company, Limited. The deceased was 57 years of age.

Mr. F. Brockhouse, a director and works manager of J. Brockhouse & Company, Limited, Victoria Works, Hill Top, West Bromwich, died recently at the age of forty-six.

The Hon. Alfred Erskine Gathorne-Hardy, a Railway Commissioner and Chairman of the Light Railways Commission, has been found dead in his study at Donnington Priory, Newbury.

Mr. J. P. Stockbridge, whose death is announced, was the manager of the Close Works, Gateshead, of Sir W. G. Armstrong, Whitworth & Company, Limited. He was 35 years of age.

The death took place suddenly at 268, Bath Street, Glasgow, on November 9, of Mr. William Jacks, of the Scottish Cast Iron Brazing Company, 124, Elmbank Street, Glasgow. The deceased was 52 years of age.

Second Lieut. G. K. P. Wood, Lancashire Fusiliers, who was killed in action, was the eldest son of Mr. A. P. Wood, of Whitefold, Hale, Cheshire, the managing director of the Lancashire Dynamo & Motor Company, Limited, Trafford Park, Manchester.

The death took place on November 6, at 57, Osborne Road, Newcastle-on-Tyne, of Lieut. V. Oswald Davis, R.E. (S.R.), manager of the Newcastle-on-Tyne branch of the British Thomson-Houston Company, Limited. The deceased was 33 years of age.

The death has taken place at Upholland of Mr. James Wright, a well-known Lancashire foundry master, at the age of 88 years. The deceased gentleman, prior to his retirement from active business a few years ago, was a partner in the firm of Messrs. J. & T. Wright, of the Fir Tree House Foundry, Platt Bridge, near Wigan.

Capt. G. N. Adams South Staffs. Regiment., who died last month, was the son of Mr. G. N. Adams, one of the directors of George Adams & Sons, Limited, Mars Iron Works, Wolverhampton. His uncle, Mr. T. B. Adams, was the other director of the firm, while the deceased had also been associated with the business prior to the war.

The death took place last month, at his residence, 1, Broomhall Park, Sheffield, of Mr. E. H. Marples, in his 84th year. The late Mr. Marples was one of the men who helped to make the name which Sheffield holds to-day as the great steel centre. He was the son of Mr. William Marples, the senior representative of an old Derbyshire family. Born at Sheffield in 1835, he was educated at Sheffield Grammar School. On the death of Mr. William Marples, founder of the well-known Hibernia Steel Works, in Westfield Terrace, the deceased and his brothers undertook the management of the business, which rapidly forged ahead until it took its place as one of Sheffield's leading steel firms, with a world-wide reputation. Mr. Marples was also senior director of Turner, Naylor & Company, Limited, engineers' tool makers, Northern Tool Works, John Street, Sheffield.

Applications for Patents.

The names of communicators are printed in Italic type. A new number will be given when the Complete Specification is accepted.

Anderton, J. and L. Apparatus for casting metallic, etc., bodies. 17,288. October 23.

Bloxam, A. G. (*Stabilimente Biak—Ing. A. Pouchain*). Tin soldering and tin-coating aluminium or aluminium alloys. 17,739. October 30.

Munro, H. Methods of casting shells. 17,205. October 22.

Price, C. F. Crucible furnaces for melting aluminium, etc., for casting purposes, etc. 17,151. October 21.

Vergniaud, L. Manufacture of crucibles. 17,253. October 22.

Vergniaud, L. Drying crucibles artificially. 17,254. October 22.

Wardle, A. Foundry moulding, etc., machines. 16,967. October 17.

Williams, W. H. Crucible furnace. 16,772. October 15.

Legal.

Assessment of Works Engaged on Munitions.

A case of importance to the occupiers of manufacturing premises containing machinery has been decided in the Court of Quarter Sessions for the County of Middlesex, after a hearing extending over two days. The appellants were S. Smith & Sons (Motor Accessories), Limited, who were appealing against the assessment to the Poor Rate of their works at Cricklewood, and the respondents were the Assessment Committee of the Parish of Willesden.

The appeal was in respect of a rate made in April, 1917, and chargeable in two instalments, the assessments being for the first instalment, gross estimated rental £3,645, rateable value £2,430, and for the second instalment gross estimated rental £4,720, rateable value £3,147. Each of these assessments were objected to on the ground that in arriving at the assessment the machinery upon the premises had been rated, and that the assessments were thereby excessive, and not in accordance with the legal decisions on this question. The valuers for the Assessment Committee claimed that by the decision of the House of Lords in the case of Kirby v. Hunslet (1905) they were entitled to value the engineering machinery as if it were rateable.

The Court decided against the Assessment Committee and reduced the rateable value for the first instalment of the rate from £2,430 to £1,437, and for the second instalment from £3,147 to £1,915.

The rating surveyors engaged as witnesses for the appellants were Mr. H. E. Elkins (Humphreys-Davies & Company), 5, Laurence Pountney Lane, London, and Mr. H. H. Fuller, 15, Serjeant's Inn, London, and for the respondents Mr. A. L. Ryde, of Messrs. Ryde & Sons, 49 and 50, Parliament Street, Westminster, and Mr. P. Ryan, of 1, Albemarle Street, London, W.

Trade Talk.

ALFRED HERBERT, LIMITED, have established a branch at Kokura, Japan.

THE STEEL INGOT MAKERS' ASSOCIATION has given £3,656 to the King's Fund for the Disabled.

IT is proposed to form a National Association of Iron Merchants, to cover the stock-keeping section of the trade.

THE Board of Trade have refused a licence under the Non-Ferrous Metal Industry Act to Messrs. R. Katz & Co.

THE GRAHAME-WHITE AVIATION COMPANY, LIMITED, will in future be known as the Grahame-White Company, Limited.

MESSRS JAMES SANDERS & COMPANY, tinplate and metal merchants, have removed to 39, Exchange Buildings, Swansea.

KENNEDY'S (CARNTYNE) LIMITED, engineers and valve makers, are making considerable additions to their works at Carntyne, N.B.

A WINDING-UP order has been made against the Blackwall Engineering & Welding Works, Limited, 221, West Ferry Road, Millwall.

THE HAMMON ENGINEERING COMPANY, LIMITED, is being wound up voluntarily, with Mr. M. G. Dadley, Hertford Street, Coventry, as liquidator.

MESSRS. J. H. KORNER and P. C. Grivas, engineers, Cardiff, trading under the style of J. H. Korner & Grivas, have dissolved partnership.

THE MIDLAND GALVANISED HOLLOWARE COMPANY, LIMITED, is being wound up voluntarily with Mr. W. C. Peach, 81, Bescot Road, Walsall, as liquidator.

THE MERTON METALLURGICAL COMPANY, LIMITED, is being wound up voluntarily, with Sir Woodburn Kirby, Bassishaw House, Basinghall Street, London, E.C., as liquidator.

THE NEW ERA TOOLS & STAMPINGS, LIMITED, of Bisley Street, Streatham Common, S.W., have had a winding-up order made against them at the Wandsworth Court.

A SCIENTIFIC research association in the interest of engineering and shipbuilding is to be established by the North-East Coast Institution of Engineers and Shipbuilders.

MESSRS. SHELDON & Co., gauge makers, Penzance Works, Sheffield, have converted their business into a private limited liability concern under the name of Oliver V. Beckerlegge, Limited.

NEWTON BROS. (DERBY), LIMITED, are making considerable additions to the buildings and plant at their Alfreton Road Works, Derby, which, when completed, will practically double the works capacity.

THE BOARD OF TRADE have found it possible to make some relaxations in the existing import and export prohibitions. A preliminary list of the articles affected has been published, and further relaxations will be announced from time to time.

THE partnership heretofore subsisting between Messrs. W. L. Smith, C. S. Walker, E. R. Smith, and R. L. Smith, engineers, etc., 33, Tothill Street, Westminster, London, S.W., under the style of Smith, Walker & Company, has been dissolved.

JOHN DAVIS & SON (DERBY), LIMITED, are making further extensions to their All Saints' Works. The extensions comprise additions to the instrument and scale departments and machine shop, the erection of a garage and a new mess room for the employés.

THE partnership heretofore subsisting between Messrs. T. Watson, H. G. Shoolbred, and F. C. Webb, engineers, 1, Langley Street, Luton, trading under the style of T. Watson & Co., has been dissolved. Mr. T. Watson will continue the business under the style of Thomas Watson.

IT is claimed that the latest zinc smelting plant installed in this country, one recently erected in the Midlands by the Ridge Furnace and Engineering Company, Limited, is already giving better results both as regards costs and efficiency than obtained by pre-war German practice.

MR. W. HOLEHOUSE, engineering director of the Davenport Engineering Company, Limited, and patentee of the Bradford cooling tower, has severed his connection with the company, and is commencing business at 21, Morley Street, Bradford, on his own account to design and manufacture special cooling plant for large turbines.

EMPLOYERS holding posts vacant for the return of serving officers, or men of similar educational standing, and wishing to apply for their priority release from the Army, should write to the Directorate in their own district of the Appointments Department, Ministry of Labour, in order to save unnecessary delay.

THE MINISTER OF MUNITIONS gives notice that all deliveries of steel for export shall continue to be made at prices fixed by the Minister. Information as to the export prices ruling on and after November 18 will be obtainable on application to the Ministry of Munitions (Controller of Iron and Steel Production), Whitehall Place, S.W.

THE committee appointed by the Board of Trade under the chairmanship of Sir Dudley Stewart-Smith, K.C., to consider applications for licences under the Non-Ferrous Metal Industry Act, 1918, have reported to the Board of Trade that the total number of applications received up to October 4 was 1,575. The number of licences issued was 901.

IT was announced at the annual meeting last month of Dick, Kerr & Co., Limited, that a provisional agreement for amalgamation has been entered into with the Coventry Ordnance Works, Limited, a private company, with shares and debentures amounting to £1,400,000, owned by John Brown & Co., Limited, Cammell, Laird & Co., Limited, and the Fairfield Shipbuilding & Engineering Company, Limited.

THE CHANCELLOR OF THE EXCHEQUER states in the Parliamentary papers that it has been decided to set up a Ministry of Supply for the public service generally to be developed out of the existing organisation of the Ministry of Munitions, and the duty of disposing of all surplus Government property will be undertaken by the Ministry of Munitions pending the completion of the arrangements for organising the new Ministry.

ARCHD. BAIRD & SON, LIMITED, are engaged upon important extensions to the Clyde Steel & Engineering Works, Hamilton, N.B. These include extending the steel foundry bay by 100 ft., the building of new dressing shops and stores, and the erection of an entirely new machine shop, together with the installation of a range of modern tools. This last was rendered imperative to meet the growing demand for finished castings.

ACCORDING to an announcement by the Minister of Munitions, until further notice, iron and steel makers are at liberty to accept and execute orders for iron and steel ranking for priority below Class B, subject only to conditions shortly to be issued as regards prices, and to the Order as to priority, dated March 8, 1917. For this purpose the operation of such clauses of the Control of Steel Supplies Order of November 20, 1916 (as amended by the Order of December 14, 1917), as prohibit the manufacture of iron and steel for orders ranking below Class B is suspended.

As from December 1, 1918, all restrictions as to the sale or purchase of calcium carbide are removed, subject to a maximum price to consumers of £40 per ton for quantities of 1 cwt., and over (granulated 10s. per ton extra). No application for the use of this material or returns of stock, need now be made to the Ministry of Munitions. It is anticipated that supplies will be available for all purposes, and will be distributed through the ordinary trade channels, but should the exigencies of the shipbuilding trade demand it, the Government reserve the right to give preferential deliveries.

THE BRITISH METAL CORPORATION, LIMITED, has been registered with a nominal capital of £5,000,000 in

MOULDING MACHINES

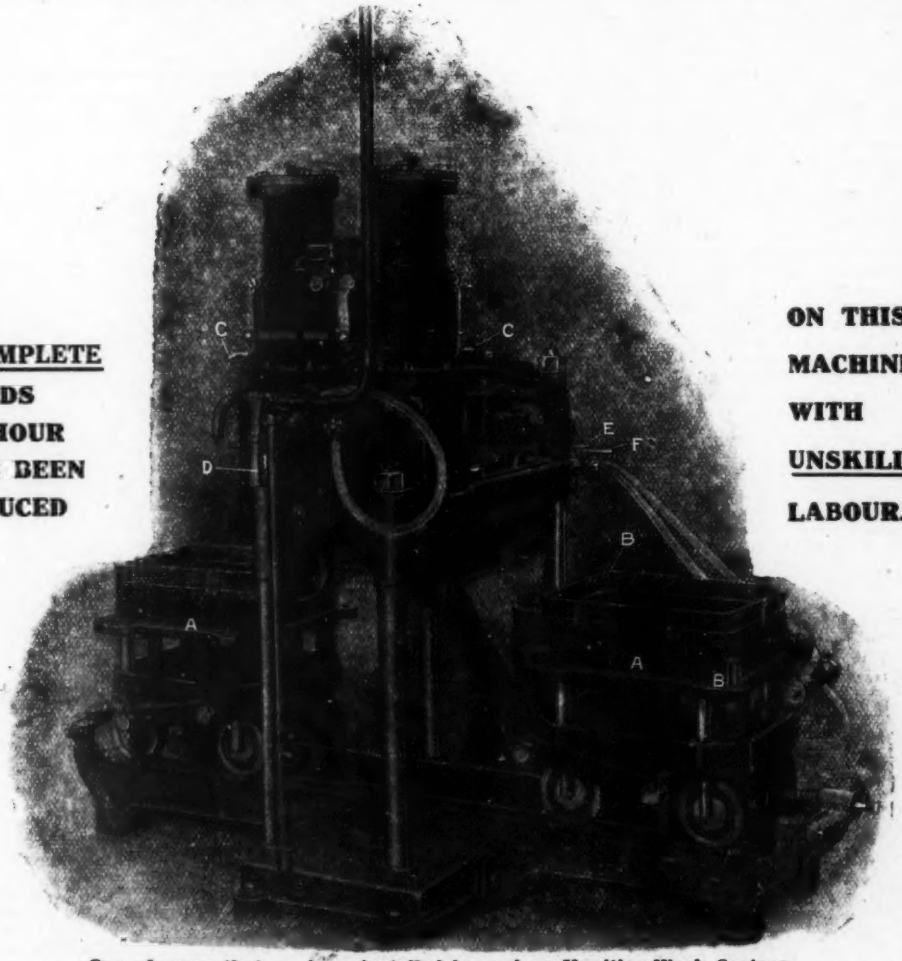
OF EVERY DESCRIPTION.

Pneumatic, Hydraulic, Jar Ramming, & Hand Power.

Type "A" Duplex Machine for Pneumatic Power.

Fitted with self-adjusting Rammer Head which accommodates itself to any varying depth of pattern.

OVER 50 COMPLETE MOULDS PER HOUR HAVE BEEN PRODUCED



ON THIS MACHINE WITH UNSKILLED LABOUR.

One of many that we have installed in various Munition Work Centres.

JAMES EVANS & CO., BRITANNIA WORKS, BLACKFRIARS, MANCHESTER.

500,000 shares of £10 each. The objects as defined in the memorandum of association are to buy, sell, manufacture, and deal in ores, metals, minerals, etc., and to act as capitalists financiers, etc. The signatories to the memorandum of association (each subscribing for 1,000 shares) are Cecil R. Rudd, C. W. Fielding, C. Sale, V. H. Smith, A. J. H. Smith (Newcastle-on-Tyne), A. W. Tait, and W. L. Tennant. Share warrants to bearer are prohibited. The Treasury has the permanent right to be represented by one director. The first directors are to be appointed by the subscribers to the memorandum of association.

THE office of the secretary of the new London Iron and Steel Exchange, Limited, is at 113, Queen Victoria Street, E.C.4, and for the purposes of its business the exchange has secured the great Pillar Hall of Cannon Street Hotel. On this the directors are to be congratulated, since there is no better or more convenient hall for the purposes of such an exchange in the whole of the city of London. The exchange has been formed by a group of some forty of the leading British firms engaged in the iron, steel and metal industries. It comes into being at an auspicious moment, when the whole tide of industrial activity is being turned from purposes of war to those of peace.

THE full report of the Imperial War Conference sittings is now published. One of the first subjects that came under discussion was the non-ferrous metal industry and the legislation that has taken place in the United Kingdom on the subject. The Conference resolved (Resolution II.) :—In pursuance of the policy of freeing the Empire from dependence on German-controlled organisations in respect of non-ferrous metals and ores, the Conference endorses the principle of the Non-Ferrous Metal Industry Act of the United Kingdom, and recommends the Governments of the Empire to adopt effective measures, in so far as these may be necessary and have not already been taken, to carry out this policy.

THE MINISTER OF MUNITIONS announces that contractors in possession of plant and machinery owned by the Ministry of Munitions who wish to use such plant and machinery for civil work may do so on condition that they notify the Superintendent Engineer in their area within one week from the date on which the plant and machinery was first used for purposes other than those for which it was provided. The use of such plant and machinery will impose no obligation on the contractor to purchase, or on the Ministry to sell, although should a sale not be effected to the contractor he will be required to pay a reasonable hire (which, unless an agreement exists to the contrary, will in no case exceed the rate of 20 per cent. per annum on the cost price of the machine), and also to release the machine when required to do so by the Minister.

THE annual meeting of the members of the Decimal Association was held at the Manchester Hotel by permission of the British Electrical Federation, the chair being taken by Mr. T. McKenna. The chairman referred in his speech to the progress which had been made during the past year, which had resulted in the introduction into the House of Lords of a Decimal Coinage Bill; the subject is now being considered by a Royal Commission of which he is a member. He also alluded to the recent considerable increase in membership and revenue, and gave as further evidence of progress the issue of a quarterly journal. The report was approved, and fresh rules for the Association and its branches were passed. The past members of the executive were re-elected, and the committee was further strengthened by the election of Mr. E. M. Rodocanachi, Mr. D. Scott, and Mr. C. Turnbull.

THE MINISTER OF MUNITIONS has appointed a Demobilisation Board to deal with all measures affecting the demobilisation of munitions works and the liquidation of contracts, apart from the questions assigned to the Resettlement Board under the Minister of Labour. The Board will consist of the following members :—Sir James Stevenson, Bart., chairman; Mr. H. H. Piggott, secretariat; Sir Stephenson Kent, labour; Mr. W. T. Layton, priority; Sir Arthur Duckham, liquidation of contracts (aircraft and engines); Sir Gilbert Garnsey, liquidation of contracts (all other contracts); Mr. Alexander Walker, disposal and sale of stores; Sir Keith Price, disposal of factories, etc.; Major-General the Hon. Sir F. R. Bingham, military services. The secretary of the Ministry (Sir W. Graham Greene, K.C.B.), the assistant secretary (Mr. J. E. Masterton Smith), and the chairman of the Finance Committee will be ex-officio members of the Board. The Board will be assisted by the following expert advisers : Mr. S. Dannreuther, Sir Philip Henriques, Sir John Mann, Mr. W. J. Larke. Financial Departmental representatives will also be attached to members of the Board. The Board will continue to be advised on Labour matters by the Resettlement Board, under Sir Stephenson Kent, who remains a member of the Munitions Council.

IN order to facilitate dealings with Government Departments the following trade sections have been formed by the Wholesale Hardware Association :—Wire Nail Section: Chairman—Mr. Oswald Nettlefold, J.P. (Nettlefold & Sons, Limited). Honorary Secretary—Mr. R. A. Cowman (Rd. Johnson, Clapham & Morris, Limited). Committee—Mr. J. H. Barlow (Chas. Homes), Mr. F. M. Burris (Fred. Burris & Sons), Mr. W. E. Galloway (W. Galloway & Company), Mr. S. B. George (John George & Sons, Limited), Mr. H. Gibbons (Gibbons, Skinner & Company), Mr. W. Grace (Daniel Layborn & Company), Mr. F. A. B. Lord (W. F. Dennis & Company), Mr. J. G. Scott (Thomas Scott & Company, Limited), Mr. J. R. Wallwork (J. Atkinson & Co.). Wholesale Machinery and Tool Importers: Chairman—Mr. T. W. Simpson (John Shaw & Sons, Wolverhampton, Limited). Committee—Mr. F. M. Burris (Fred Burris & Sons), Mr. A. R. Findlay, Mr. W. G. Hatch (George Hatch, Limited), Mr. R. G. Keddell (John George & Sons, Limited), Mr H. G. King (Burton, Griffiths & Company, Limited), Mr. J. H. Neal (Charles Churchill & Company, Limited), Mr. E. E. Preston (A. A. Jones & Shipman, Limited), Mr. E. A. Savage (Buck & Hickman, Limited). Tube-fittings, Valves, and Engineering Specialities: Chairman—Mr. R. Osborne (Edward Le Bas & Company). Honorary Secretary—Mr. D. MacIntyre (E. Bennett & Sons, Limited). Committee—Mr. J. E. Bennett (E. Bennett & Son, Limited), Mr. R. S. Golding (The Fairbanks Company), Mr. J. R. R. Robb (The Scottish Tube Company, Limited), Mr. H. W. Spencer (The Crosby Valve & Engineering Company, Limited), Mr. J. M. Strausner (Stanley G. Flagg & Company (England), Limited), Mr. W. H. Utz (Jenkins Brothers, Limited). Other Sections: The formation of three other sections is nearly completed, viz.: 1. Agricultural. 2. Lighting and Heating (Gas and Oil). 3. Hardware Factors.

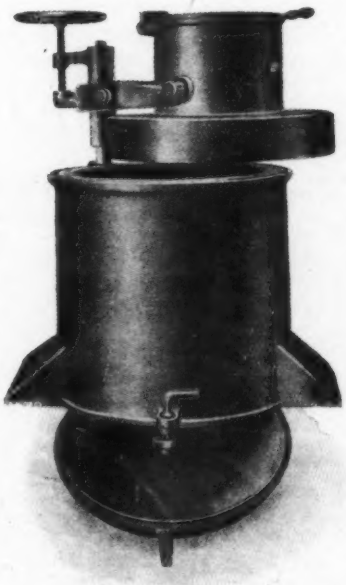
THE MINISTRY OF MUNITIONS have issued an official notice to contractors, sub-contractors and workpeople engaged on work for the Ministry. The great task before the country is the transformation of industry from war to peace. The following instructions are issued to all factories and firms engaged on work for the Ministry :—There should, so far as possible, be no immediate general discharge of munitions workers. All workers, however, who desire to withdraw from industry or to leave for any reason, and all workers who can be absorbed elsewhere, should be at once released. Production on contracts for guns and gun ammunition, machine-guns, small arms, and small-arms ammunition; trench warfare mortars, bombs and stores, pyrotechnic stores; aerial bombs; all accessories of the above stores; aircraft and aero-engines; and the manufacture of explosives, should be reduced in the following way :—All overtime should be immediately abolished. Systems of payment by results should be temporarily suspended, and the customary notice of the transfer from payment by results to time work should be given. When a

MACNAB & Co.,

56/8, Eagle Street, Southampton Row, LONDON, W.C.1.

Reduce your fuel cost! Melt in a hurry!

For Brass, Gunmetal, Aluminium, Iron, etc.



Tylor Patent Pit-Type Furnace.

OUTPUT.

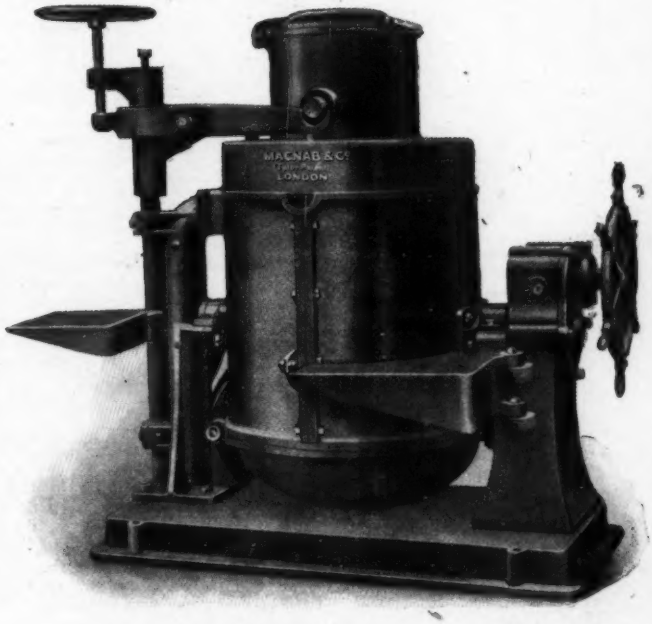
200 lbs Admiralty Gunmetal melted in 25 minutes. Temperature 2000° F.

ECONOMY.

20 lbs. of Coke used per 200 lbs. of Metal melted.

STANDARD CRUCIBLES.

Lasting 35 to 40 heats.



Tilting-Type Furnace.

OUTPUT.

400 lbs. Admiralty Gunmetal melted in 45 minutes. Temperature 2000° F.

ECONOMY.

73 lbs. of Coke used per 400 lbs. of Metal melted.

STANDARD CRUCIBLES.

Lasting 35 to 40 heats.

transfer to time work has taken place a reduction of the hourly week should, wherever possible, be introduced. The reduction of hours will also apply to men already on time work, and in their case the customary procedure as to reduction of hours should be followed. Whenever reduced hours are worked on a time-work basis, the number of hours worked must not be less than one-half of the hours in the present normal working week of the establishment. If in any case the earnings of the workpeople for the full weekly number of hours on the short-time system fall below the following amounts :—Men of 18 years and over, 30s. per week; boys under 18, 15s. per week; women of 18 years and over, 25s. per week; girls under 18, 12s. 6d. per week; their earnings will be made up to these sums by the employer, who will be reimbursed by the State. Where time is lost, the amounts payable will be sums proportionate to the number of hours actually worked.

Material for Industry.

Standing Council on Post-War Priority.

The War Cabinet recently set up a Cabinet Committee to deal with post-war priority questions. This Committee consists of General Smuts, the President of the Board of Trade, the Minister of Labour, the Minister of Shipping, the Minister of Munitions and the Minister of Reconstruction. The secretary is Col. Byrne, C.M.G., 11, Pall Mall, S.W. A Standing Council on post-war priority has been appointed to assist the Cabinet Committee, and is now at work. The Council has already had before it a survey of the existing stocks of the more important raw materials, and is giving urgent consideration to the question of releasing such materials from any form of control at the earliest possible moment. It is the intention of the Council to consult the trade bodies concerned with regard to any matters affecting the industries they represent.

The personnel of the Council is not yet complete, but it is felt that as it is already in session a public announcement on the subject is called for. The following are the members of the Council who have already been nominated (additional Labour representatives have been invited to join the Council and their names will shortly be announced) :—

President : The Right Hon. Christopher Addison, M.D., M.P., Minister of Reconstruction.

Chairman : Sir Henry Birchenough, K.C.M.G.

Members : Sir Kenneth Anderson, K.C.M.G., Orient Steam Navigation Company, London, Ministry of Shipping; Mr. H. R. Armitage, Bradford Dyers' Association, Manchester; Mr. J. T. Brownlie, Amalgamated Society of Engineers; Col. Byrne, C.M.G., Secretary of the War Priorities Committee; Mr. J. Carmichael, Contractor, Wandsworth, London, S.W.; Mr. J. H. Clapham, C.B.E., Litt.D., Board of Trade; Sir Sydney Henn, K.B.E., Director of Priority, Army Contracts Department, War Office; Mr. W. J. Larke, O.B.E., British Thomson-Houston Company, Rugby, Ministry of Munitions; Sir Peter McClelland, K.B.E., Messrs. Duncan Fox & Company, London; Sir Herbert Rowell, K.B.E., R. & W. Hawthorn, Leslie & Company, Newcastle-on-Tyne; Sir David Shackleton, K.C.B., Secretary, Ministry of Labour, ex-President Trades Union Congress and ex-Chairman of National Labour Party; Mr. Wallace Thorneycroft, Lochelly Iron & Coal Company, Steel Company of Scotland; Mr. Alexander Walker, John Walker & Sons, Kilmarnock, Ministry of Reconstruction; and Mr. J. Wormald, Mather & Platt, engineers, Manchester, Chairman of the Industries Committee. Joint Secretaries: Mr. T. R. Gardiner, Ministry of Reconstruction, and Major G. D. Hazzledine, Board of Trade.

Communications should be addressed for the time being to the Joint Secretaries, Standing Council on Post-War Priority, 2, Queen Anne's Gate Buildings,

Second-hand Machine Tools, Wood-working Machinery & Treadle Lathes.

The Minister of Munitions announces that in future second-hand machine tools, second-hand wood-working machinery and second-hand treadle lathes may be bought and sold without the sanction of the Ministry and without restriction as regards price. This suspension of regulations, however, does not in any way affect the position with regard to new tools, to which the regulations still apply in their entirety. A further notification concerning new tools will be issued in the course of the next few days.

Personal.

THE late Mr. J. Rigby, engineer, of Southport, left £36,202.

THE late Mr. T. H. Wilkes, bedstead manufacturer, of Sedgeley, Staffs., left £28,201.

THE gross value of the estate of the late Mr. John Rugby, engineer, of Southport, is £40,977

THE late Mr. F. W. V. Mitchell, chairman of Winfield's Rolling Mills, Limited, Birmingham, left £160,101 with net personalty £145,779.

THE late Mr. J. H. Cassels, of Messrs. Pott, Cassels, and Williamson, engineers and ironfounders, Motherwell, left personal estate valued at £43,189.

MR. D. B. MORISON has been elected chairman of Richardsons, Westgarth & Co., Limited, of Hartlepool, Middlesbrough, and Sunderland, in succession to the late Mr. W. J. Richardson and the late Lord Furness.

DR. P. LONGMUIR, works' manager to Samuel Fox & Company, Limited, has been the recipient of a presentation from the officials and men to celebrate the occasion of the honour conferred upon him by the Government in admitting him to the Order of the British Empire.

MR. R. A. MILES is resigning his position as foundry manager with Messrs. Brooks & Doxey, Limited, of Junction Ironworks, Miles Platting, Manchester, to take up the duties of Lancashire representative for Messrs. Leigh & Sillavan, Limited, metal merchants, of Barton House, 66, Deansgate, Manchester. He commences his new appointment on January 1, 1919. Mr. Miles is a member of the Lancashire Branch Council of the British Foundrymen's Association

MR. W. J. GORDON, who was recently made an officer of the British Empire Order, has been presented by his friends at the Naval Construction Works, Barrow, with £100 in honour of this distinction. He has handed over the amount to the Barrow Education Committee to be invested in War Loan, the interest to provide a "W. J. Gordon" prize at the Barrow Technical School.

CHANGES have taken place in the secretaryships of the Shipbuilding and Engineering Employers' Associations on the Clyde and the Forth. Mr. T. Biggart has retired from the secretaryship of the Clyde Shipbuilders' Association and the North-West Engineering Trades Employers' Association, and Mr. D. Higgins, a member of his legal staff, has been appointed whole-time secretary to both bodies. The headquarters will still be in West George Street, Glasgow, and Mr. Biggart will act as hon. advisory secretary. The Scottish Association of Engineers and Ironfounders, whose headquarters are at 19, York Place, Edinburgh, have also decided to appoint a whole-time secretary, and Mr. R. Shepherd has been selected for the position.

WILLIAM JACKS & COMPANY,

LONDON AND BIRMINGHAM.

Telegrams: ALKALIZE, LONDON.
Telephone: 7880 AVENUE (3 lines.)
Head Office:
5, EAST INDIA AVENUE, LONDON, E.C.

Telegrams: ALKALIZE, BIRMINGHAM.
Telephone: CENTRAL 1175 & 1176.
Birmingham Office:
18, BENNETTS HILL.

LIVERPOOL: 11, Oldhall Street. Telegrams: LATEM, LIVERPOOL. Telephone: Central 6794.

PIG IRON.

Scotch, Middlesbro', Hematite, Basic, Specials, &c., &c.

STEEL.

Billets, Wire Rods, Tube Strip, &c.

REGISTERED TRADE MARK

COPPER.

Tough, Best Selected and Refined Ingots, Electrolytic Ingot Bars, Wire Bars, and Cathodes.

TIN.

All Brands Ingot and Bar Tin.

SPELTER.

G.O.B.'s and Special Purities.

Telegrams: FERRUM, MIDDLESBRO'.
Telephone: MIDDLESBRO' 659.
ROYAL EXCHANGE, MIDDLESBRO'.

Telegrams: COLVIN, GLASGOW.
Telephone: CENTRAL 7460.
93, HOPE STREET, GLASGOW.

WILLIAM COLVIN & COMPANY,

MIDDLESBOROUGH AND GLASGOW.

New Companies.

Composite Tool Company, Limited.—Capital £25,000 in £1 shares.

Union Zinc Mining Company, Limited.—Capital £50,000 in £1 shares.

Evans & Yeomans, Limited.—Capital £100 in £1 shares, to carry on the business of ironfounders, etc.

Blackburn Aircraft Products, Limited.—Capital £10,000 in £1 shares. Registered office: Donnington House, W.C.

Wellesley-Brown Aircraft, Limited.—Capital £5,000 in £1 shares. Registered office: 23, Suffolk Street, S.W.

Gerrard Engineering Works, Limited.—Capital £5,000 in £1 shares. Registered office:—15-19, Great Titchfield Street, W.

National Reclaimers, Limited.—Capital £15,000 in £1 shares (10,000 preference), to carry on the business of chemical manufacturers.

Clyde Engineering Company, Limited.—Capital £10,000 in £1 shares. Registered office:—187, West George Street, Glasgow.

H. Carter & Son, Limited.—Capital £10,000 in £1 shares, to acquire the existing business of zinc, iron and copper roofing contractors, etc.

Grampus Armament Company, Limited. — Capital £2,500 in £1 shares. Registered office: 33-36, King William Street, London, E.C.

Ferrotherm, Limited.—Capital £3,000 in £1 shares, to carry on the business of engineers, etc. Registered office: 57-9, Long Acre, W.C.

General Aircraft & General Engineering Company, Limited.—Capital £5,000 in £1 shares. Registered office:—6-10, Halling Road, W.6.

Morley Aviation Company, Limited.—Capital £1,000 in £1 shares. Aeroplane manufacturers, etc. Registered office: 1, Renfrew Road, S.E.11.

Oto, Limited.—Capital £2,000 in £1 shares, to carry on the business of ironfounders. Registered office: 9, River Street, Hammerton Street, Burnley.

William Loynes & Company, Limited.—Capital £500 in £1 shares, to carry on the business of engineers, etc. Registered office: Warstone Lane, Birmingham.

Crumblehulme, Limited.—Capital £15,000 in £1 shares, to carry on the business of general ironfounders, etc. The first directors are T. Brown and J. Briggs.

Cook & Co. (Manchester), Limited.—Capital £100,000 in £1 shares, to carry on the business of ironfounders, etc. Registered office: 18, Exchange Street, Manchester.

Navarro Aviation Company, Limited.—Capital £35,000 in £1 shares (15,000 10 per cent. preference

DIE-CASTING & WHITE-METALLING PLANTS

for White Metal and Aluminium Alloys, etc.

The only heat-controlled and scientifically built Plants on the Market for all soft metals.

THESE PLANTS ARE BEING EXHIBITED DURING DEC. 27 TO JAN 9 AT THE EXHIBITION OF BRITISH SCIENCE PRODUCTS, MANCHESTER.

SOLE MAKERS AND PATENTEES—

THE MONOMETER MANUFACTURING CO. (1918) Ltd., Whitehouse St., ASTON, BIRMINGHAM.

LEGGE'S IRON CEMENT.

The most efficient for general Engineering and Foundry Work.

It repairs permanently and effectively makes good all defects in Castings, leaking parts and connections in Steam, Water, Gas and Air, etc.

WRITE TO MANUFACTURERS—

16, South Castle St., **F. THOMPSON LEGGE &CO.** LIVERPOOL.

FERRO-VANADIUM. * * * * **FERRO-TITANIUM.**

SILICO-MANGANESE { **23/30 %** Silicon. **65/70 %** Manganese and **1 %, 2 %, 3 %**, Carbon Maximum.

FERRO-SILICON Containing **25 %, 50 %, 75 %** Silicon.

FERRO-CHROME **65/70 %** Cr. & **1 %** up to **8/10 %** Carbon Maximum.

MAGNESIUM METAL **99 %.** *In Sticks and Powder and Magnesium Copper.*

WE SUPPLY ALL CLASSES OF MINERALS, METALS AND METALLIC ALLOYS.

EVERITT & CO., 40, CHAPEL ST., LIVERPOOL.

Telegrams: "PERSISTENT." Telephone No. 1134 (3 lines).

MOTOR CYLINDERS!

If you wish to be successful in the manufacture of the above it is essential that you use

"SPERMOLIN"

(Registered Trade Mark)

for your CORES, which will overcome all difficulties.

AS SUPPLIED TO H.M. WAR OFFICE.

For particulars apply to the Makers:—

THE SPERMOLIN CORE CO.,
HALIFAX.

Telegrams:—"SPERMOLIN, HALIFAX."
Telephone: 397 HALIFAX.

and 20,000 ordinary). Registered office: 5, Victoria Street, S.W.

W. L. Bodman, Limited.—Capital £12,500 in £1 shares (10,000 preference), to carry on the business of ironfounders. Registered office: 41, Finsbury Pavement, E.C.

Tappets, Limited.—Capital £5,000 in £1 shares, to carry on the business of aeroplane valve manufacturers. Registered office: Advance Works, Kingsthorpe Road, Northampton.

A. Camden Pratt & Company, Limited.—Capital £20,000 (12,000 10 per cent. cum. pref. shares of £1 and 64,000 ord. shares of 2s. 6d. each), to carry on the business of engineers.

Manchester Aluminium Company, Limited.—Capital £5,000 in £1 shares. The first directors are J. D. Paton and J. Ashworth. Registered office: 25, Market Street, Manchester.

Engineers' Founders, Letchworth, Limited.—Capital £5,000 in £1 shares, to acquire the business formerly known as Ernest Farmer & Sons and latterly as G. A. Spill, Letchworth, Herts. The first directors are G. A. Spill and A. A. Blaker.

C. S. Peatfield, Limited.—Capital £2,500 in £1 shares, to take over the engineering business carried on by C. S. Peatfield at Market Rasen, Lincs. The first directors are C. S. Peatfield, S. E. Wilson and F. B. Jevons (all permanent). Registered office:—Waterloo Street, Market Rasen, Lincs.

Drabble & Sanderson, Limited.—Capital £20,000 in £1 shares, to carry on the business of merchants and manufacturers of steel, iron, etc. Governing director, A. K. Wilson. Other directors: L. J. Coombe, D. J. Haggie, T. Darwin and E. N. Cooper. Registered office:—Ebenezer Works, Morpeth Street, Sheffield.

Slough Metal Company, Limited.—Capital £1,000 in £1 shares, to take over the business of scrap metal brokers, etc., carried on by S. J. Stanley at 19, William Street, Slough, Bucks, as S. J. Hoffman. The permanent directors are R. Goddard and A. L. Alexander Registered office:—65, William Street, Slough, Bucks.

Eureka Ball Bearings, Limited.—Capital £3,000 in £1 shares, to take over the business of Fletcher & Parker, St. James's Chambers, 38, Church Street, Sheffield, Thomas Street, Sheffield, and 9, Hall Gate, Doncaster. A. Fletcher is managing director for life. Registered office: St. James's Chambers, 38, Church Street, Sheffield.

Refractory Materials.

From October 1 last no person may deal in any of the materials specified in the schedule below at a price exceeding that stated except under permit issued by the Minister of Munitions.

All applications under the order should be made to the Deputy Controller of Iron and Steel Production, Ministry of Munitions, 8, Northumberland Avenue, London, W.C.2. The order is cited as the Refractory Materials (Maximum Prices) Order, 1918.

Description.	Maximum prices f.o.r. makers' works.	
	England, Wales and Ireland.	Scotland.
Firebricks—Highest grade:		
9 in. by 4½ in. by 3in. squares	152/6 per 1,000	152/6 per 1,000
9 in. by 4½ by 2½ in. "	135/- "	
Blast furnace linings and special bricks	77/6 per ton	77/6 per ton
Best quality ground fireclay ..	24/- "	24/- "
Gas retorts, to standard specification	11/- per foot.	11/- per foot

Dust Fan.

High Pressure Fans.

Volumetric Fan.

Fans for Ventilation, for Dust Removal, for Induced & Forced Draft on Boilers.

...TRADE... SIROCCO ...MARK...

FANS

Cupola and Forge Fire Fans for large or small duties. Reliable and efficient.

Davidson & Co., Limited.,

Sirocco Engineering Works.

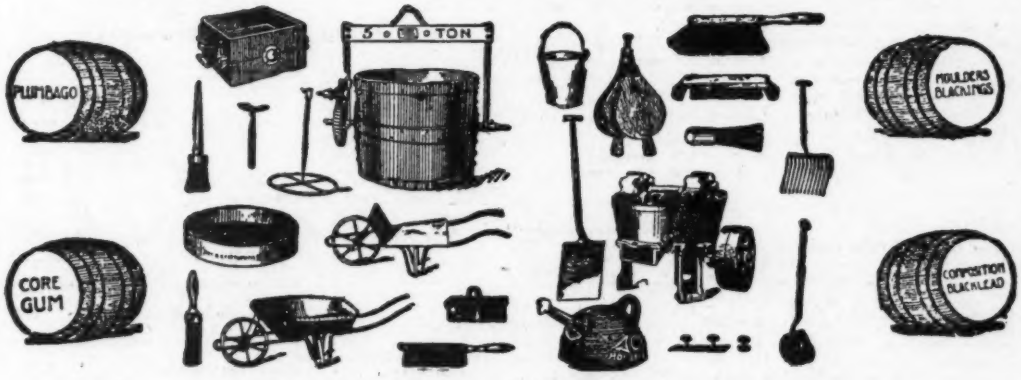
BELFAST.

Telegrams: "Durrans, Penistone." Telephone: 21, Penistone

Established 1863.

JAS. DURRANS & SONS,

Phœnix Works, Penistone, Near Sheffield.



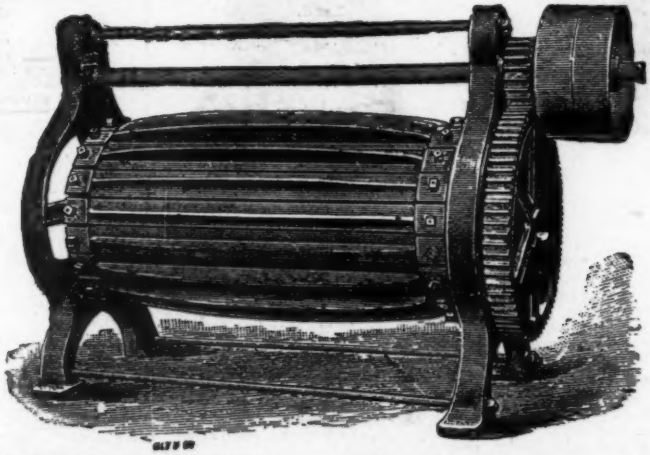
Manufacturers of all

FOUNDRY EQUIPMENTS

COMPOSITION BLACK LEAD, PLUMBAGO, CORE GUM, WHITE DUST & COAL DUST

Ladles, Cupolas, Fire Bricks, Gannister, Stone Flux, Loam and Sand Mills, Casting Cleaners, Studs, Chaplets, Pipe Nails, Sprigs, Brushes, Wire Brushes, Core Ropes, Bellows, Buckets, Spades, Forks, Riddles, Sieves, Barrows, Etc.

Improved Foundry Rattler or Fettling Drum.



These Machines are invaluable for a Foundry, doing a larger amount of work of a superior quality, in a much shorter time than can be done by hand, without skilled labour.

The following testimonial explains itself :—

"Dear Sirs,—We have been using your best Blacking for a large number of years, and always use it on our large Ingot Moulds, which, as you know, we have made up to 85 tons in weight.

Yours faithfully, THE BRIGHTSIDE FOUNDRY & ENGINEERING CO., LD.

MONTHLY PRICE LIST.

The undermentioned prices, unless otherwise specified, are those obtaining at the commencement of the current month.

CONTROL PRICES.

Pig-Iron.

	£	s.	d.
West Coast hematite, mixed Nos. 1, 2 and 3	6	7	6
Special under 0.03 P. & S... ..	6	15	6
" " 0.02 "	7	0	0
East Coast hematite, mixed Nos. 1, 2 and 3	6	2	6
Special under 0.04 P. & S. ..	6	7	6
Special under 0.03 P & S. ..	6	15	6
" " 0.02 "	7	0	0
Scotch hematite, mixed Nos. 1, 2 and 3..	6	2	6
Special under 0.03 P. & S. ..	7	10	0
Welsh hematite, mixed Nos. 1, 2 and 3	6	2	6
Special under 0.03 P. & S. ..	6	15	6
" " 0.02 "	7	0	0
HEMATITE—MALLEABLE—			
Refined—			
Refined Cupola Cast	8	0	0
Refined Cupola Cast to guaranteed analysis..	8	5	0
Cast direct from Blast Furnaces—			
Small Pig-Iron, all grades ..	7	10	0
Medium Pig-Iron White to Grey mottled	7	5	0
Medium Pig-Iron, all other qualities	6	17	6
Large Pig-Iron, all grades ..	6	17	6
Lincolnshire, basic or foundry ..	4	17	6
Cleveland, No. 1	4	19	0
" other grades	4	15	0
" basic	5	0	0
Northamptonshire, forge	4	7	6
" fdy numbers	89/6		94/6
" basic	4	17	6
Derbyshire, forge	4	10	0
" foundry numbers	92/6		96/6
Derby & Notts. basic.	4	17	6
Leicestershire & Notts., forge ..	4	10	0
" " foundry nos.	92/6		96/6
North Staffs, forge	4	15	0
" " foundry	4	17	6
" " basic	4	17	6
South Staffordshire—			
Part mine forge	5	0	0
" foundry	5	2	6
Common Staffordshire ..	4	15	0
All mine forge	5	15	0
" foundry	6	0	0
Warm air forge	7	5	0
" foundry	7	15	0
Lord Dudley's silicon	8	7	6
Cold blast	9	2	6
Basic	4	17	6
Scotch foundry and forge—			
Nos. 3, 4, and lower grades of Monkland, Dalmellington, Eglinton, and Govan.. ..	5	14	0
Nos. 3, 4, and lower grades of all other brands	5	15	6

No. 1 quality in all cases to be 5s. per ton above these prices.

All per ton net, f.o.t. makers' works.

Mers. Com. 1½%

In all districts 1s. extra may be charged for Basic cast in chills.

High-Speed Tool Steel.

The maximum prices for high-speed tool steel have been fixed as follows:—

Finished bars, 14% Tung. 3s. 8d.

Finished bars, 18% Tung. 4s. 5d.

Per lb. basis. Extras as per authorised list. These prices are net delivered buyers' works.

The fixed prices for scrap which must be returned to steel makers' works are as follows:—

Millings and Turnings	8d.
Bar Ends	9d.

Both per lb. net delivered steel makers' works.

Ferro-Alloys

Net, Delivered Sheffield steel works.

	£	s.	d.
Ferro chrome: 4/6% carbon. Basis 60%, scale 10s. per unit Per ton		—	
Ferro-chrome: 6/8% carbon. Basis 60%, scale 10s. per unit. Per ton		—	
Ferro-chrome: 8/10% carbon. Basis 60% scale, 10s. per unit Per ton		—	
Ferro-chrome: Specially refined, guaranteed maximum 2% carbon broken to small pieces for use in best quality crucible steels. Basis 60%, scale 32s. per unit. Per ton		—	
Ferro-vanadium: 33/40% Va., per lb. of Va. contained in the alloy		—	
Ferro-silicon: 45/50%. Basis 50%, 5s. scale per unit .. Per ton		—	
Ferro-titanium: 23/25%, per lb. carbonless..		—	
Ferro-molybdenum: 70/80% Mo. per pound of Mo. contained ..		—	
Ferro-phosphorus: 20/25%. Per ton		—	
Ferro-tungsten: 75% to 80% per lb. of metallic tungsten contained		—	
*Ferro-manganese 80%	26	10	0
" export —		—	

* F.o b. Liverpool.

Non-Ferrous Metals.

Copper.

	£	s.	d.	£	s.	d.
Standard, Cash	..122	0	0	122	10	0
Three months	..122	0	0	122	10	0
Electrolytic ..	..137	0	0	133	0	0
Tough ..	..135	0	0	131	0	0
Best selected ..	..135	0	0	131	0	0

Tin.

Standard, Cash	..274	10	0	275	10	0
" Three months	269	10	0	270	10	0
English Ingots	..277	0	0	—		
Bars	..278	0	0	—		
Refined	..	—		—		

Spelter.

Ordinary	.. 56	0	0	52	0	0
Specials.. ..	..	—		—		
Hard	.. 44	10	0	45	10	0
British	..	—		57	0	0

Lead.

Soft Foreign (net)	.. 40	10	0	39	10	0
English	..	—		Nom.		

Antimony.

Regulus	..	—		80	0	0

Aluminium.

Virgin Metal 98/99% per ton	—		—

Phosphor Bronze.

INGOTS.	Per ton
Alloy No. I. or II	—
III., IV. or V.	—
VI. or VII.	—
VIII.	—
XI.	—
Cast Strips and Ingots.. ..	—
CASTINGS.	Per lb.
I. or II.	—
III. IV. or V.	—
VI. or VII	—
VIII.	—
XI.	—
No. VII., Chill, Cast, Solid ..	—
" Cored Bars	—

Delivery 2 Cwt. free to any town.

10 per cent. Phosphor Copper ..	£50 above price of best selected copper.
15 per cent. Phosphor Copper ..	£70 above price B.S.
Phosphor Tin (5 per cent.) ..	£30 above price of English Ingots.

(Phosphor-bronze prices supplied by CHARLES CLIFFORD AND SON, LIMITED, FAZELEY STREET MILLS, BIRMINGHAM).

***Chromium (Metallic).**

98/99% purity, per lb.	—		—

***Nickel.**

In cubes, 98/99% purity Per ton			—

Nickel Silver.

	per lb.
Ingots for raising	—
Ingots for Spoons and Forks ..	—
" rolled to spoon size ..	—

***Tungsten Metal Powder.**

98/99% purity.. per lb. ..	—

***Molybdenum Metal.**

98/99% purity.. per lb. ..	—

***Cobalt Metal.**

97% purity .. per lb. ..	—

Quicksilver.

75 lb. bottle	—

* Net, Delivered Sheffield Works.

Scrap Iron and Steel.

	s.	d.	s.	d.
Cleveland.				
Steel scrap, heavy melting..	—		—	
Iron scrap cast (cupola metal)	—		—	
London (f.o.b.).				
Heavy steel			104	6
Light "			55	0
Heavy cast			110	0
Control Prices.				
Heavy Steel Melting Scrap 105	0		125	0
Steel Planings, Turnings and Borings			65	0
Steel Planings, Turnings and Borings mixed with Wrought Iron, &c.			50	0
Steel Scrap, all other Classes ..			95	0
Wrought Iron Scrap			125	0
Ditto, mixed with Steel			95	0
W.I. Planings, Turnings and Borings mixed with Steel, &c.			50	0

Per ton delivered Buyers' Works.

Cast-Iron Scrap.

	£	s.	d.
Hy. ord. brkn., between 1½ cwt. and 10 cwt.	4	15	0
Hy. machy., brkn., bet. 1½ cwt. and 10 cwt.	5	0	0
Cold blast, brkn., bet. 1½ cwt. and 10 cwt.	6	15	0
Ingot mould, unbroken	6	0	0
Ditto, brkn., bet. 5 cwt. and 2 tons	6	5	0
Ditto, between 1½ cwt. and 5 cwt.	6	10	0
Extra for breaking into pieces not exceeding 1½ cwt.	0	5	0
Railway chairs for re-melting ..	5	0	0
Heavy lumps, not above 2 tons ..	4	12	6
Light	4	5	0
Burnt, broken, ready for cupola ..	3	0	0
Burnt fire bars	4	0	0
Turnings and borings for iron and steel makers	3	5	0

Per ton f.o.r. or f.i.b. Scrap merchants' commission, 2½ per cent.; additional 10s. allowed, except for railway chairs and turnings and borings, to cover inwards carriage and handlings on sales from scrap yards.

Coke.

	s.	d.	s.	d.
Middlesbrough.				
Gas Coke	—		55	0
Foundry	65	0	70	0
Glasgow.				
Foundry Coke	—		47	0
Furnace Coke	37	0	—	
London.				
Welsh or Durham Foundry, d/d London Stations in truck	45	0	53	0
Ditto, d/d Birmingham Stats.	44	0	46	0
Yorkshire, d/d London Stations, in truck	42	6	—	
Ditto, d/d Birmingham Stats.	39	6	—	

CONTROL PRICES OF COKE.

	s.	d.
Scottish blast furnace	35	0
" foundry	45	0
Durham & Northumbd. blast furnace	33	0
" foundry	38	0
Yorkshire, Lancashire, Staffordshire, Notts., Derbyshire, Lincs., & Midland Counties blast furnace	32	6
Ditto. foundry..	45	0
Ditto. steel melting (Sheffield Dist.)..	54	0
South Wales blast furnace ..	37	6
" foundry	50	6
All per ton net. f.o.t. ovens.		
Cumberland blast furnace .. .. d/d West Coast furnaces	37	9

SITUATIONS VACANT AND WANTED.

FOUNDRY FOREMAN WANTED by large firm in the Midlands; must be energetic, with sound practical and theoretical knowledge of Foundry Work in all its branches, both malleable and grey iron, more especially the former; repetition work; good prospects; no person already on Government work will be engaged.—Apply, with full particulars, salary required, etc., to your nearest Employment Exchange, quoting No. A. 6236.

FOUNDRY FOREMAN would like change; 21 years' practical experience in Loam, Drysand, and Greensand Castings, Iron, Brass, and Aluminium. Energetic; able to keep down costs, etc.; first class testimonials.—Apply, Box 134, Offices of the FOUNDRY TRADE JOURNAL, 165, Strand, London, W.C.2.

CHEMIST, young, seeks situation. Steelworks and non-ferrous works analysis. Experience with requirements of Electric Steel Foundries.—C., Box 132, Offices of the FOUNDRY TRADE JOURNAL, 165, Strand, London, W.C.2.

WANTED, Core Maker, accustomed to oil engine and cylinder work; also Iron and Brass Moulders. Standard District Rate and Bonus.—The Hamworthy Engineering Company, Limited, Poole, Dorset.

YOUNG MAN seeks situation as Foundry Foreman. Age 31, thoroughly experienced in Marine and Hydraulic work, Coremaking and Moulding. &c.—Address, Box No. 138, Offices of the FOUNDRY TRADE JOURNAL, 165, Strand, London, W.C.2

FOUNDRY FOREMAN wanted. Must be energetic, with sound practical and theoretical knowledge of Foundry work in all its branches, both Malleable and Grey Iron, more especially the former. Repetition work. Good prospects. No person already on Government work will be engaged.—Apply, with full particulars, salary required, etc., to Bullers, Limited, Tipton, Staffs.

IRONFOUNDER who is growing old, desires to find someone, with a good knowledge of Foundry Work, to take his place in a sound and old-established business in the Midlands. Preference given to a Public School Man who has served in the war. Facilities afforded to him, when proved suitable, to acquire an interest in the Business, and gradually assume control.—Box No. 128, Offices of THE FOUNDRY TRADE JOURNAL, 165, Strand, London. W.C.2.

FOR SALE AND WANTED.

SELF-CONTAINED Coke Fired Core Oven, made by Phillips, with Radial Shelves. In new condition.—H. Pickup, Brook Street, Scarborough."

FOR SALE in London, cheap to save removal, 30-in. Evans cupola, complete with blower, staging, roof, and hoisting tackle. Very good order, ready for work.—Address, Box 130, Offices of THE FOUNDRY TRADE JOURNAL, 165, Strand, London, W.C.2.

BRITISH PATENT No. 108,426, of 1916, relates to a drop flask Moulding Machine, whereby the system of moulding is rapid, accurate and inexpensive. Sale or licence.—TURNER, 28, Plumper's Road, Sheffield.

TO IRONFOUNDERS and users of Steel Castings.—Crucible Steel Furnace for sale, quite simple and most economic. Advantages: (1) Low consumption of coke; (2) long life to crucible; (3) most rapid in melting; (4) little cost in starting to make steel castings; (5) tensile stress between 30 and 40 tons per sq. in.; (6) results guaranteed.—Address, Box 994, Offices of the *Foundry Trade Journal*, 165, Strand, London, W.C.2.

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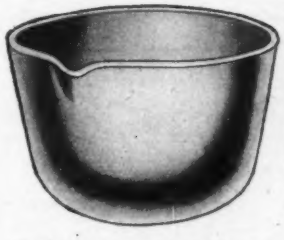

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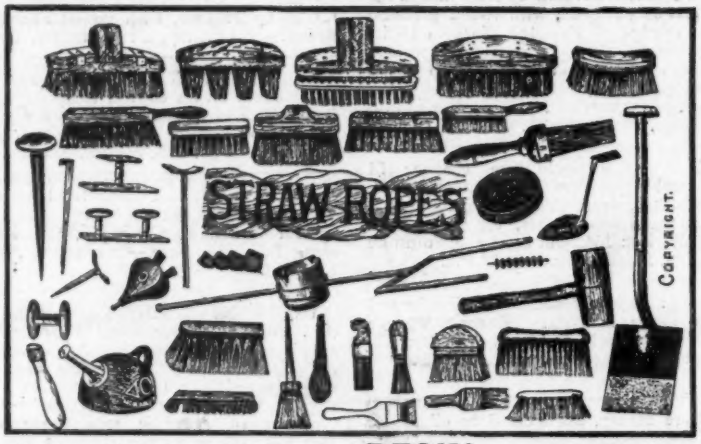

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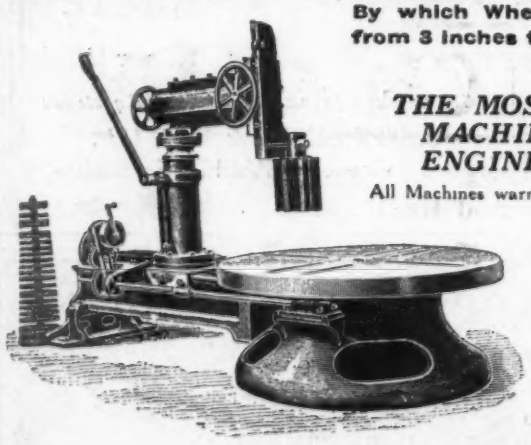

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All Machines warranted to Mould with the greatest accuracy and precision.

GEARING WHEELS

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Makers of GANISTER BRICKS and FIRECLAY GOODS of every description.

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For Light Castings. Saves Drying in Stoves.

Compositions for

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GROUND GANISTER FOR ALL KINDS OF FURNACES. SILICA CEMENT.

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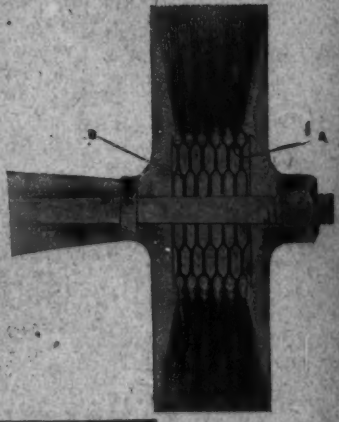
for cleaning Castings

are really Economy Sections set in and welded between two-sheet Metal Discs.

¶ There is no time required to place them on hub or retaining device. They are simply held between flanges of an ordinary emery grinder (as illustrated).

¶ In this way Brushes of any width desired are available at once and without cost of wider hubs, which have to be made to order.



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		Inches.	R.P.M.	Each.
Natar	8 diam.	1	2100-2400	4/-
Nitor	15 ,,	1¼	1200-1600	5/-

(Subject to Discount).

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Dividing Wheel of large diameter, cut from master wheel 21 ft. dia.

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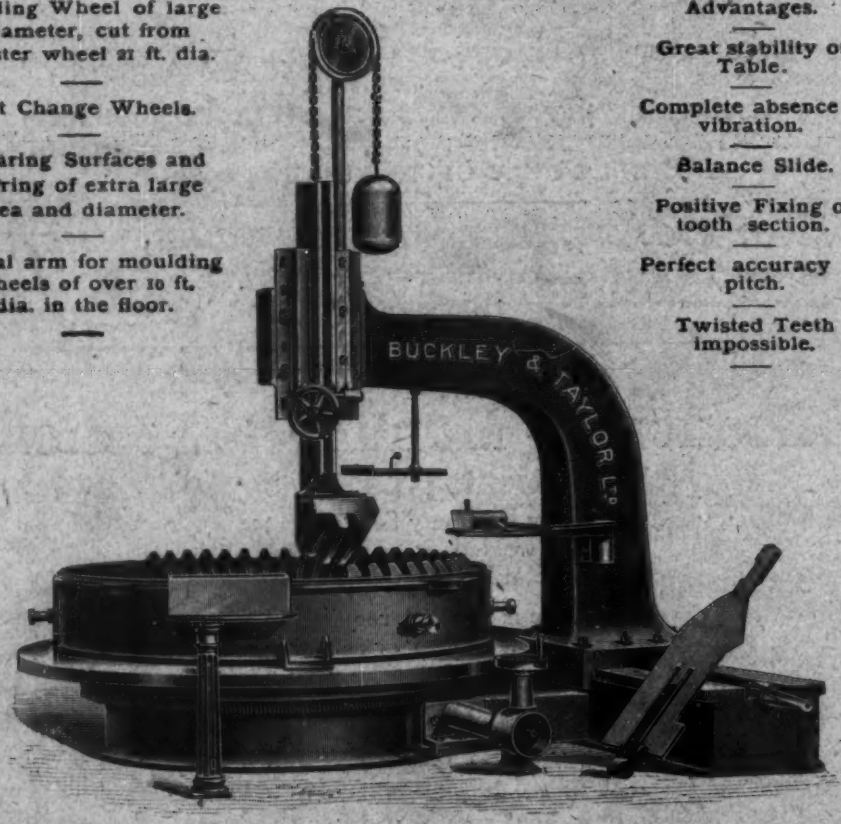
Wearing Surfaces and Bearing of extra large area and diameter.

Radial arm for moulding wheels of over 10 ft. dia. in the floor.



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Great stability of Table.

Complete absence of vibration.

Balance Slide.

Positive Fixing of tooth section.

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Twisted Teeth impossible.

Used by most of the principal steel and iron founders in this country, and also in the United States, Canada, Russia and China. Made in eight sizes for moulding wheels, from 4 inches to 10 ft. in diameter on the table, and up to 30 ft. diameter in the floor.

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